

HARC Online Workshops > Societal Vulnerability and Impacts > Introduction

Post Title: Introduction

Posted by: *Larry Hinzman* at 4:05 PM 4/9/2002

Hydrology crosses nearly all aspects of our lives, impacting how we dress, where we may travel, how much our food costs, our very health. From an engineering or economic view, changes in the hydrologic cycle may have drastic consequences in arctic regions. These consequences may be lessened if we have the opportunity to prepare or at least anticipate these potential impacts. Ameliorating the effects of climate change to the global or arctic ecosystem may already be beyond the capabilities of society, but humanity has demonstrated resilience and adaptability to change.

*Do we need to take any action and if so, what actions?

*Is it time to prepare for change or will society gradually adapt as the system changes?

*Focusing upon processes related to the hydrologic cycle, what changes should we expect will have the greatest or most immediate impacts upon society?

*What research is most immediately necessary to address these questions?

Please help us to document where research is most needed to address questions of societal vulnerability and impacts to change.

HARC Online Workshops > Societal Vulnerability and Impacts > Societal Vulnerability and Impacts

Post Title: Societal Vulnerability and Impacts

Posted by: *Julie Sprott* at 5:14 PM 4/15/2002

I'm learning a lot from the discussion and I see that it touches on many of the topics listed on the table "Human Dimension Impacts" provided in the introduction to the workshop. My immediate question concerns the involvement of rural resident stakeholders in the process. To what degree do we understand or have knowledge of the ways local residents gauge their situation (and all the ramifications of global warming) and what research has been done to elicit their priorities for research in this area? What are their top concerns? Do we know? The Denali Commission is apparently doing a lot of applied survey work in rural communities as a means to assist them to think about their priorities for infrastructure improvements. What about doing the same for eliciting their concerns about global warming effects at the village level and ask them to prioritize them and to additionally come up with proposed solutions or need for assistance? There is so much research that could be done, but by what criteria should decisions be made for selection of topics for funding? Should the "greatest good for the greatest number" be the primary consideration (like conditions which are most generalized across villages regardless of location such as sanitation and clean drinking water)?

From the discussion, it sounds to me that assisting coastal communities in danger of shoreline erosion is close to top on the list, but should research dollars be spent in dealing with that issue when the remedy apparently requires massive governmental funding for relocation? Do the three threatened communities mentioned thus far regard relocation as their only choice? I ask that because I spoke with an individual who was in Kivalina recently and who related that there remains a large contingent in the village strongly opposed to relocation. The stress generated within the community by this division must be staggering. Researching processes of village decision-making for "corrective" actions related to global change effects is a topic worthy to pursue in its own right (and touches on some of Henry Huntington's and Larry Hamilton's comments made earlier, e.g., the need for survey research on community opinions and responses to shoreline erosion).

Post Title: Re: Societal Vulnerability and Impacts (Julie Sprott)

Posted by: *Henry Huntington* at 10:11 AM 4/16/2002

Excellent points about community involvement in asking questions, setting priorities, making decisions, etc. One weakness of our usual approach is that we take either the natural or the social environment as static and then examine the dynamics of the other half of the equation, rather than looking at both the natural and the social systems as dynamic (and coupled, at least loosely). In terms of community decisions, this often translates into "Everything's fine except for climate change, which will have a huge impact" instead of "Things often change, and climate change may add another source of change." Kivalina has been eroding for a long time, and the community would have had to deal with that regardless. One question is how they have handled these challenges over time. Certainly, it's easier to move if you have not built a school, water plant, houses, etc. But we shouldn't regard erosion (or other impacts in other cases) as something that simply happens to the community, which is then a passive recipient with static social conditions. Instead, many things are going on in all the communities around the Arctic, some of which are forcing changes in economics, demographics, and other aspects of society. That's why I like the approach Kenneth Johnson has described in Canada, where the

researchers present what is likely to happen in the physical environment (e.g., beach erosion is likely to do XX), and then the community has the chance to determine what this is likely to mean for them, in the context of their other concerns, priorities, and trends.

Amanda Lynch has a HARC project on the impacts of changes in sea ice in Barrow (see <http://www.arcus.org/harc/research> for details), part of which is examining the policy implications and how the North Slope Borough does or does not incorporate the likely consequences of a changing environment. More work like this is a good idea.

Post Title: Re: Societal Vulnerability and Impacts (Henry Huntington)

Posted by: *Julie Sprott* at 12:35 PM 4/16/2002

I agree, Henry, that we are dealing with highly dynamic systems in both the social and physical realms. I'd appreciate knowing more about experiences people have had with collaborations with local communities up front in the process, as I haven't been involved in this type of research. I apologize if my questions and comments are so naive. Basically, I was asking who is fueling the need to know and where research questions derive in this arena. On a post elsewhere, someone commented whether outsiders care about climate change in the arctic and potential and real effects on arctic communities to start with. I was trying to turn that issue 180 degrees and ask to what degree we understand that local (and presumably affected) communities themselves, the Insiders, are concerned about these issues. Is the research being supported or in the works something the villagers are solidly behind and have requested be done or are we proposing to present to them future scenarios and models of change that might not be that salient to them?

Post Title: Re: Societal Vulnerability and Impacts (Julie Sprott)

Posted by: *ffeqs* at 12:59 PM 4/16/2002

To follow up on Julie Sprott's inquiries, I was wondering what kind of impact studies were done before the construction of the Dempster Highway (if any were done at all), and similarly, in response to Ken Johnson's posted document, if anyone knows about the recent decision of the community of Tuktoyaktuk to build a road to Inuvik and what kind of impact assessments were done (if any) in conjunction with these proposals?

Post Title: Re: Societal Vulnerability and Impacts (Julie Sprott)

Posted by: *Henry Huntington* at 2:02 PM 4/16/2002

I don't think there are any naive questions at this point! (Or, maybe most or all of our questions in this area are naive!) As far as who is driving the research questions and priorities, I'd say it's a mix. Some villages (or villagers, perhaps) are concerned about things like erosion and changes in sea ice, snow cover, and so on. I've heard many concerns expressed in several communities, and some (Kotzebue, for instance) have undertaken some projects to document changes they are seeing. A lot of other research is being driven by the scientists, who are exploring the ramifications of the changes they observing or anticipating in models, etc. Some are a mix--Amanda Lynch's project mentioned in my earlier post is an example, where the researchers came up with the original ideas, but then worked with Barrow to refine the questions and address issues of local importance.

Post Title: Re: Societal Vulnerability and Impacts (Henry Huntington)
Posted by: *Carol Jolles* at 12:58 PM 4/17/2002

As I was reading through the posts on this topic and the related topics from previous days, it occurred to me that while we talk about levels of vulnerability in local arctic communities, we still have not managed to set up fora that truly involve local communities directly. Rather we either seem to talk among ourselves and then bring our concerns TO the communities for review (carrying our agendas with us) or we go to the communities and then return to scientific fora and again discuss among ourselves ways to approach the issues of concern (introducing our research agendas after the fact). The implicit hierarchies that operate in such exchanges of concerns and information are never really dealt or even openly discussed.

I'd like to see HARC on-line workshops dealing with such sensitive issues as beach erosion, water safety, changes in ice densities, etc., start with invitations to the concerned communities to participate in the on-line discussions, with direct assistance given to them to promote interaction if necessary. If local community members were involved in such discussions more directly, there might be some way to assist the communities through scientific-local partnerships that could avoid some of the possible pitfalls involved when these communities try to address problems growing out of a variety of problems that could be categorized as societal vulnerability. Granted not all of these are directly related to climate change, but often they are at least peripherally related to a combination of ecological changes and globalization.

For example, in March I attended a meeting in Diomedede between staff members from the U.S. Army Corps of Engineers and the local community to discuss the possibility of building a small boat harbor for the Diomedede community which has just voted NOT to move to the mainland after much local debate. This harbor project, which would take approximately ten years to fund and build, has the potential to change the coastline of Diomedede and to cause at least as many problems as it will attempt to solve. The community views the project as a benefit, in part, because they do not have the resources or background to address all of the possible environmental impacts which will undoubtedly combine with ongoing changes in ice conditions, etc., of which they are already aware. The Army Corps of Engineers staffers, however, presented a picture of a project which could be built and would "benefit" the Diomedede community, although there seemed to be little evidence that the Corps had ever attempted to build a harbor project in such a difficult and potentially sensitive location. There was no discussion of possible environmental impact.

It seems to me that there must be some way for the scientific community to assist local arctic communities early enough in the project development process to assist communities while, at the same time, avoiding a patronizing role. I guess this is both a plea for more partnerships and a question about how such partnerships can be profitably developed to help communities deal realistically with the changes that will inevitably occur in their communities as a result of global warming.

Post Title: Re: Societal Vulnerability and Impacts (Carol Jolles)
Posted by: *Henry Huntington* at 12:01 PM 4/18/2002

This from Alex Whiting, Environmental Protection Officer, Native Village of Kotzebue:

The water cycles of Arctic communities, from the storage, to transportation through the community, to discharging back into the environment, with minimal if any, effective treatment

are areas that need research. And as communities continue to expand in population every year the problems are exacerbated. Many times solutions can be devised but there is no one to pay the cost, but creating solutions is the first step. The community of Kotzebue currently faces the issue of a limited water supply and ability to effectively treat wastewater. I have worked on these issues with the City, including the concept of watershed protection areas (which has still not garnered any enthusiastic response) and the only long term reliable solution to either problem involves engineering challenges and lots of money. As a poor rural community we are dependent on the government for major infrastructure needs. In addition, just surviving from day to day as a public works department, keeps everyone busy and it is hard to develop long-term costly solutions while operating under "crisis management". The Tribe is interested in connecting with researchers and developing projects that, while achieving the academic goals of the researchers involved, also fulfill the needs of the Tribe. For instance we are currently beginning a NSF project this summer that will hopefully result in a profile of the benthic community of Kotzebue Sound and how local pollution (wastewater discharge) has affected this part of our ecosystem. We also explored the technology being developed out of Fairbanks by Dave Maddux of constructed wetlands for rural Alaska water treatment. My point being is that researchers in any particular field doing work in the Arctic can accomplish their goals while providing a tangible benefit to the community, if the projects are jointly developed from the beginning through a collaborative effort between the Tribe (community) and researchers. As in the NSF study, the goal of the researchers was to study the invertebrates of Kotzebue Sound while a high priority for the tribe was more to determine the negative consequences of massive discharge of community wastewater, both these objectives can be achieved during the same project. The Tribe will now have access to skilled technicians, labs, and crews to collect, transport, analyze and document findings, something that would be extremely more difficult for the Tribe to do unilaterally.

While the immediate future needs of water supply and wastewater consumes most of the thought and energy of Arctic communities, there is the larger picture of the continued unsustainable fossil fuel/chemical consumer driven global societies and their ultimate effect on the Arctic and the peoples that live in it. In other words will the cumulative effect of chronic oil spills, polluted military sites, community pollution, long range contaminant transport, and non-point and point sources of industrial/development pollution, combine over time to make the Arctic and indeed much of the planet hostile to human existence. In other words it is not worth much to have subsistence needs and priorities, and indeed wildlife conservation strategies, recognized if the plants and animals are polluted beyond safe consumption limits and the ability to reproduce and sustain themselves. This concern arises more readily in the Arctic because of the bare bones nature of it, compared to temperate and tropical areas, and its ability to effectively take this load out of biotic circulation and trap it in an inert way or completely break it down. The major problem with research along these lines, is the identification and documentation of these conditions is limited in its ability to correct the problems. Without a complete change in the way people relate to their world and live, it seems that we will continue to sail along in that direction until the breaking point is reached and we no longer have any choice but to live with the consequences. If the Arctic Ocean or some of its seas become large "Lake Erie's", will we have the ability to remediate? Especially while still carrying on all the same activities that got us to that point in the first place. Of course the only thing left to us, if we can't change the way people do things, is to investigate and document what is happening so we can try to mitigate as much as possible, until that point of no return is reached.

HARC Online Workshops > Societal Vulnerability and Impacts > Need for grey and black water reclamation to reduce need for potable water supply and environmental

Post Title: Need for grey and black water reclamation to reduce need for potable water supply and environmental

Posted by: *Aleta Fowler* at 2:19 PM 4/17/2002

There are two linked issues in the North. First, potable water is expensive (see CMHC Report, Utility Costs in Northern Communities). For an average household, based upon consumption of 10,000 litres per month, costs range from \$19 in Labrador (as sewage is discharged directly into the ocean); to \$68 in Yukon; to \$225 in Nunavik; to \$283 in NWT; and finally to \$536 in Nunavut (reasons for this range is outlined in the report). Getting the water to the residence has environmental impact (truck diesel, roads over permafrost areas, etc.). High costs result in low water consumption resulting in health issues. Health Canada recommends a minimum of 65 litres of water per person per day. In some communities in the Canadian North, consumption is less than 30 litres per person per day. With socialized health care, this has a direct effect on our health system.

Second, on the disposal side, most communities make use of lagoons. However several communities still discharge directly into water bodies, or directly onto the land. Enough said on that. Lagoons are failing as permafrost degrades. Numbers for lagoon remediation are not yet available, but are estimated to be, at a minimum, 50% of the total operationalizing/commissioning cost of the lagoon.

CMHC has found it is economical and feasible to take the grey and black water produced by households, "reclaim" it and cleanse it (there are several technologies which are proving viable - see articles on our web site <http://www.cmhc-schl.gc.ca> in particular those at <http://www.cmhc-schl.gc.ca/en/burema/gesein/abhose/nose/>) If reclaimed, cleansed water is used for toilet flushing and laundry, not only does water consumption rise to healthier levels, but the demand for potable quality water drops by over 50% (as high as 62% in some test sites). In some test sites, this reclaimed, cleansed water has also been used for showering, replacing 80+% of household potable water.

On the disposal side, there is no longer an environmental impact as all the household water has been cleansed to "swimming pool" quality standards (as established in the US). Therefore water discharged into the environment is "clean", making lagoons no longer a hazard as permafrost-bound berms fail or leeching occurs with thaw. Disposal on-site is no longer a hazard.

For copies of any of these reports, you can contact me (afowler@cmhc-schl.gc.ca), or our main library at chic@cmhc-schl.gc.ca.

HARC Online Workshops > Societal Vulnerability and Impacts > Hunting, Fishing, Gathering

Post Title: Hunting, Fishing, Gathering
Posted by: *Henry Huntington* at 5:26 PM 4/11/2002

We typically look at traditional hunting, fishing, and gathering activities in terms of their relation to the resource being harvested (e.g., sustainable or unsustainable, etc.), or occasionally in terms of access--use of sea ice for hunting marine mammals, use of snow for traveling across to hunt geese in spring, etc. Relating these activities to the hydrological cycle specifically is probably a new area of research. One approach that comes to mind is to review the seasonal round of activities, including the effects of typical variations in climate from year to year, and to use that review to assess the times, places, and activities where snow, ice, and water are critical (access, migration, habitat, etc.). Then, using the results of hydrological modeling, monitoring, etc., we can evaluate the potential impacts and continue by looking at resilience, alternatives, and so on to help figure out the overall vulnerability of a given community to hydrological changes.

Post Title: Re: Hunting, Fishing, Gathering (Henry Huntington)
Posted by: *Kreg Ettenger* at 1:58 PM 4/13/2002

One thing I am looking at in the eastern James Bay region is the cumulative impact of environmental changes on such subsistence uses. The major influence on regional hydrologic cycles in this area is hydroelectric development, specifically the La Grande complex, which either diverted or increased flows to several major rivers flowing into James Bay. Besides the obvious effects on the rivers themselves, this has impacted salinity, currents and other features of the bay, and may be impacting marine flora (such as eelgrass) and fauna. There have also been effects on use of these areas by Cree hunters due to changes in ice conditions on the rivers and bay, creating new hazards due to increased or decreased winter flows in the rivers.

There is also the compounding effect of climate change, which in recent years has led to (or contributed to) highly variable ice conditions on the bay. This past winter, for example, trappers could not reach large islands in the southern part of James Bay due to areas of open water and unstable ice between the islands and the mainland. This not only affects their yearly harvests and income, but can upset trapline management practices as well (for example, by leading to overpopulations of beaver and other species on the islands).

Perhaps more significant is the impact that such changes are apparently having on waterfowl migration patterns through the region. Changes in the dates and rapidity of ice breakup on the rivers and bay may be contributing to major shifts in migratory routes of Canada geese and other waterfowl, so that traditional coastal hunting sites are quickly becoming obsolete. Many Cree coastal hunters have already shifted their spring hunting activities to inland areas on lakes, rivers, and the reservoirs created by the hydro projects, where early migrating geese now seem to be concentrating. While some hunters have apparently been able to adapt successfully to such changes, I have concerns regarding what such trends may mean in terms of transmission of traditional ecological knowledge, as well as on local social structures (particularly the relations between generations).

These are all subjects I think are worthy of exploring on this thread, and in future research efforts.

Kreg Ettenger

Post Title: Re: Hunting, Fishing, Gathering (Kreg Ettenger)

Posted by: *Henry Huntington* at 10:25 AM 4/15/2002

I like Kreg's ideas a lot. The James Bay case may be extreme in that hydro dams are the largest cause of hydrological change, but one can also look at that case as an example of what major disruptions (from any cause) might do. One research project along these lines might be to document hydrological changes in river systems together with local understanding of hydrology and the associated ecology and human activities, as Kreg has done in James Bay. Then, one can assess the degree to which the local communities are resilient or vulnerable to the changes, not just in terms of having alternative sources of food (or being able to switch the timing and/or location of harvests) but also in terms of traditional knowledge and safety. I.e., are people having to engage in less familiar activities in places or times that they don't know as well, which may lead to higher risk of accidents?

The next question is, where might such a study take place? I think we'd want a location that has good hydrological information or on-going research, plus communities that are active in their environment through hunting, fishing, etc. I also wonder whether the Mackenzie Basin Impact Study looked at these questions, and in what detail?

Post Title: Re: Hunting, Fishing, Gathering (Henry Huntington)

Posted by: *Tom Osterkamp* at 1:03 PM 4/17/2002

The points discussed have been very pertinent and it may be worthwhile to add a few more. Historically, there are always areas of permafrost, typically near the southern margins, where most of the permafrost is very close to thawing. With climatic cooling, this permafrost will aggrade but with climatic warming this permafrost will thaw. Climate has been warming for more than a century and, coincidentally, permafrost in many areas on earth has been warming and thawing. This is consistent with observations in Alaska. These observations have defined the magnitude and approximate timing of the warming and have delineated natural areas where permafrost is currently thawing. A point of concern is that the warming and thawing appear to be accelerating at a time when global circulation models predict increased warming. Research delineating the response of permafrost to changes in climate is needed to develop better models that predict more precisely the interactions between climate and permafrost. The results would allow improved assessments of the impacts of thawing permafrost.

The warming of the last century and our subsequent observations have shown us what impacts to expect as a result of permafrost thawing. This is an important point in these discussions. We are not theorizing about what "might" happen; we have already observed the impacts of permafrost thawing on infrastructure and subsistence.

People who live on ice-rich permafrost are often made acutely aware that permafrost forms the foundation on which they live. This foundation is held together by ice and when that ice melts the foundation dissolves. When infrastructure is impacted, a frequent question is, "Was this a result of climatic warming". As Vlad points out, it is most likely due to the effect of the infrastructure on the permafrost although some portion of it must be due to climatic warming. It is hopeless to try to separate these effects.

The impacts of thawing ice-rich permafrost on infrastructure are quickly noted; however, while permafrost has been thawing for more than a century, impacts occurring in the environment and

on ecosystems have hardly been noticed until recently. Quite likely, subsistence hunters and gatherers noticed the impacts but they are receiving new recognition from scientists. Over several decades, the impacts can be major resulting in the partial or total destruction of boreal forest ecosystems that are then replaced by different ecosystems. Generally, this seems detrimental to caribou and some terrestrial animals and birds but favorable to moose and aquatic mammals and birds. Research is needed to further delineate these impacts.

Monitoring thermal conditions in permafrost provides us with information on rates and magnitudes of changes in the permafrost as well as its thermal state. Such information is necessary to determine the "health" of the permafrost, as Vlad already mentioned, and to assess potential impacts. However, this is commonly considered a monitoring activity. While this type of activity is being viewed more favorably by funding agencies, some proposal reviewers still do not consider monitoring to be mainstream science. As a result, a proposal for monitoring may have a poor rating mixed in with others making it impossible to fund. A way out of this dilemma needs to be found.

Two papers about the impacts of thawing permafrost on infrastructure and subsistence are attached [see abstract below].

Osterkamp, T. E., L. Viereck, Y. Shur, M. T. Jorgenson, C. H. Racine, A. P. Doyle, and R. D. Boone, **Observations of thermokarst in boreal forests in Alaska**, Arctic, Antarctic, and Alpine Research, 32(3), 303-315, 2000.

Abstract

Thermokarst is developing in the boreal forests of Alaska where ice-rich discontinuous permafrost is thawing. Thawing destroys the physical foundation (ice-rich soil) on which boreal forest ecosystems rest causing dramatic changes in the ecosystem. Impacts on the forest depend primarily on the type and amount of ice present in the permafrost and on drainage conditions. At sites generally underlain by ice-rich permafrost, forest ecosystems can be completely destroyed. In the Mentasta Pass area, wet sedge meadows, bogs and thermokarst ponds and lakes are replacing forests. An upland thermokarst site on the University of Alaska Campus consists of polygonal patterns of troughs and pits caused by thawing ice wedge polygons. Trees are destroyed in corresponding patterns. In the Tanana Flats, ice-rich permafrost supporting birch forests is thawing rapidly and the forests are being converted to minerotrophic floating mat fens. At this site, an estimated 84% of 2.6×10^5 ha was underlain by permafrost a century or more ago. About one half of this permafrost has partially or totally degraded and is influenced by thermokarst. Thaw subsidence at the above sites is typically 1 to 2 m with some values up to 6 m. Much of the discontinuous permafrost in Alaska is extremely warm so that it is highly susceptible to thermal degradation. Additional warming will result in the formation of new thermokarst.

HARC Online Workshops > Societal Vulnerability and Impacts > CLIMATE CHANGE IMPACTS ON PERMAFROST

Post Title: CLIMATE CHANGE IMPACTS ON PERMAFROST
Posted by: *Kenneth Johnson* at 8:06 AM 4/12/2002

Global climate change has particular significance for the permafrost environment. Contrary to what its name implies, permafrost is inherently unstable. If climate warming takes place in a permafrost area, the ground temperature at depth will respond with the possibility that the permafrost would be destabilized. Changes will be felt at the surface first, propagating into the ground slowly. In the North American Arctic, tens of thousands of square kilometres of permafrost are within one or two degrees Celsius of the melting point. Therefore, much of the permafrost environment would be profoundly affected by the transition to a warmer climate. In addition, the physical and mechanical properties of permafrost as an engineering material are temperature dependent, and this dependence is most pronounced at temperatures within one or two degrees Celsius of thawing. With a temperature increase, due to climate warming or changes in surface conditions, frozen soil will weaken. On complete thawing, it will lose its strength due to ice cementation, with implications for the stability of slopes, structures and foundations.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Kenneth Johnson)
Posted by: *Henry Huntington* at 10:31 AM 4/15/2002

A couple questions come to mind in regard to Kenneth's permafrost comments. First, (and I posted a similar comment in the Infrastructure & Development thread) how do the engineering specifications to which current infrastructure was built compare with the conditions we expect in the next few decades? I.e., do the design criteria for Prudhoe Bay and the Alaska Pipeline accommodate warmer permafrost, or did they assume stable permafrost temperatures?

Second, over what time scale are these kinds of changes likely to occur? In the oil field example, for instance, are the pipelines and buildings likely to sink into the mud before the oil is all pumped out, or will the problems really crop up in several decades when the oil fields are history? Larry Hinzman raised a relevant point elsewhere, which has to do with remediation efforts when infrastructure is dismantled, which takes place largely after the oil work is done, and thus over a longer time horizon than the oil activity itself.

In terms of research, does it make sense to conduct an engineering assessment of the design criteria and specifications for some selected (major) developments (e.g., Prudhoe and the Pipeline), and evaluate those against the changes that are expected in the next few decades?

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Henry Huntington)
Posted by: *Larry Hinzman* at 10:41 AM 4/15/2002

Following on from Henry's points, it seems all industrial development (roads, pipelines, mining) should only proceed if restoration plans are developed prior to construction. How can these plans be formalized if the final environmental conditions are unknown? The design for restoration over cold permafrost will be completely different from restoration of degrading and subsiding permafrost. Should companies be asked to develop restoration plans for various scenarios? Is that a reasonable approach given the high investment cost of development in the

North? How can a business plan be developed in such uncertain environmental and regulatory conditions?

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Henry Huntington)
Posted by: *V.Romanovsky* at 12:13 PM 4/15/2002

Henry raised very important question how engineering design takes into account possible future climatic changes. In the past, this question was simply ignored and in most cases the permafrost conditions were assumed to be stable. Recently, engineering community is trying to address this question, but the uncertainties in the future climate scenarios make these attempts very difficult to produce some useful results. The probability approach seems to be the most relevant in this situation.

So far, the largest problems related to permafrost degradation come from the impact on permafrost by engineering works themselves, not from the natural changes in permafrost because of climate change. However, the rate and the magnitude of this degradation strongly depend on the "health" of permafrost in natural conditions and there are many examples where these rate and magnitude are increasing recently.

Time scale of changes will depend on present day permafrost conditions (permafrost temperatures, active layer thickness, permafrost ice content, hydrology and so on). Presumably, discontinuous permafrost is more vulnerable than "cold" continuous permafrost. However, the specific local conditions such as, for example, the ice content in the upper layers of permafrost, or vegetation type, or changes in hydrology can significantly increase vulnerability of "cold" permafrost towards natural or human induced changes and disturbances. Also, our measurements of the thermal state of permafrost within the North Slope show that -3C and even -2C as mean annual temperatures at the permafrost table are not uncommon anymore on the North Slope and our long-time believe that permafrost there is "cold and stable" needs to be revised urgently.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (V.Romanovsky)
Posted by: *Henry Huntington* at 2:30 PM 4/15/2002

Is this an area for NSF-style research, or for the engineers to get to work? Of course, both can happen, but I'm wondering what an NSF project might look like in this area.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Henry Huntington)
Posted by: *Kenneth Johnson* at 3:29 PM 4/15/2002

The Canadian direction of engineering associated with climate change in permafrost is risk based. If the risk associated with permafrost degradation is deemed to pose a high risk then the engineering design must accommodate this accordingly. For community based projects, the risk has generally been considered low (environmental impact as opposed to community impact) therefore climate change has received very little consideration in the engineering for community projects.

The permafrost engineers and the permafrost scientists appear to have different perspectives on the importance of permafrost degradation. The engineers consider it to be important because of the potential impact on engineered structures, particularly if the degradation accelerates. The permafrost scientists consider it to be a long term occurrence with no immediate implications

because, in a general case, the thermodynamics of permafrost thaw has a timeline of hundreds of years before near zero temperatures are reached.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Kenneth Johnson)
Posted by: *Henry Huntington* at 5:01 PM 4/15/2002

Sounds like just the kind of mismatch that a good research project could examine--not that we'd resolve everything, but that we could illuminate the different perspectives and the implications of each.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Henry Huntington)
Posted by: *V.Romanovsky* at 5:36 PM 4/15/2002

Henry and Kenneth are exactly right. There is obvious gap between "scientists" and "engineers", though not always the differences in their opinion on importance of permafrost degradation are such as Kenneth described. I know many scientists (I think I am one of them) who are very worried about immediate effects of permafrost warming and degradation (like I said, the warming in the upper several meters of permafrost is practically in phase with climate and we don't need to wait hundreds and thousands of years until complete permafrost disappearance to "enjoy" all the consequences of the upper and usually the most ice-rich permafrost thaw, which can happen at some places during the next ten-to-twenty years). At the same time, I know some practical engineers who don't see any problems with permafrost for the next 20 years at least. There was good example of such opinion in an Anchorage Newspaper article (I don't remember the name but I can check if necessary).

So, the gap really exists and to fill it a NSF project, which will bring scientists and engineers together, will be a very good idea.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (V.Romanovsky)
Posted by: *Doug Goering* at 3:44 PM 4/16/2002

A number of interesting questions and observations have been posted here regarding engineering design strategy and criteria for permafrost areas. Specifically regarding Henry's questions above, my impression is that most of the existing infrastructure on the North Slope of Alaska was designed with the assumption that the existing environmental conditions would not change. Note that this does not mean that the designers assumed that the infrastructure itself would not impact local conditions. As Vladimir and others have correctly pointed out, alteration of surface conditions due to construction activity itself often has a greater impact on the local thermal regime than the projected global warming over the next few decades. Engineering design generally does consider this "warming due to construction" effect and will utilize appropriate measures to design structures to account for this. Additionally, within this design strategy will be some sort of safety factor built in, just in case the thermal impact of the structure is greater than anticipated. As a result, most engineered facilities will have some margin of safety w.r.t. environmental temperatures before serious problems occur.

On the other hand, as the climate warms we will probably begin to see increased failure rates as the safety margin is eroded. Also, if the warming is substantial enough, we may begin to see design regime shifts where, as an example, a design strategy for cold permafrost is no longer applicable in a given region. For instance, roads and work pads installed on the North Slope are generally sized to be of sufficient thickness to contain the summer thaw, thus avoiding potential

thaw strain in the permafrost. As the climate warms, the thaw potential will increase in a non-linear fashion and at some point this design technique will no longer be sufficient (no matter what the pad thickness is).

I agree that this is a potentially fruitful area for collaborative research.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Doug Goering)

Posted by: *Henry Huntington* at 3:58 PM 4/16/2002

Good points, Doug, especially about safety factors and non-linear changes. How would we go about studying this in a way that involves the permafrost scientists and the engineers?

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Doug Goering)

Posted by: *Anne Jensen* at 4:53 PM 4/16/2002

Doug is correct, but there already seem to be some failures (the Out driveway of the new Barrow Post Office has been unusable almost since it was built, and that is on a pad, with geotex & insulation under it. The depth to stable permafrost has increased in the roughly 20 years that Mike Aamodt has been setting pilings in this area (he's kept records).

Yet somehow it doesn't seem that the underlying instability of the permafrost is being communicated to working design & construction engineers. The folks who are designing the new Barrow landfill (so the old one can be clean up before the lagoon the Navy put it in breaches due to coastal erosion, spilling whatever is in the landfill as well as the contents of the primary sewage lagoon) are planning to make a pile of trash & then let it freeze and keep building that way, with permafrost being what prevents leaching, etc. I don't think it's ever been done before, at least not on this scale, but they never make clear their assumptions as to long-term stability of the permafrost, which would seem to be key in whether this will work for 50-100 years (in order to justify the astronomical cost) or just turn into a soggy pile of garbage on the tundra.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (V.Romanovsky)

Posted by: *Nikolay Shiklomanov* at 9:11 AM 4/17/2002

I absolutely agree with Vlad that probabilistic approach is a way to go in our attempts to evaluate possible impacts of permafrost changes on infrastructure. However, large uncertainties arise not only from climate scenarios but also from our knowledge of current and past Arctic climate and its relation to permafrost conditions. While changes in Arctic are apparent, we are less certain in geographical distributions of these changes and regional sensitivity of permafrost to these changes. Occurring and anticipated changes in the permafrost only become apparent in context of historical data collected prior to the 1990s. However good reliable data is extremely sparse and in many cases not linked to hydro-climatological observations. It seems like a first logical step is to quantitatively evaluate uncertainty related to our current knowledge of climate-permafrost interactions in both temporal and spatial context. Such uncertainties should be incorporated in probabilistic model, which look at broad geographic picture.

The second point is related to socio-economic changes and their influence on interactions between climate, permafrost and infrastructure. It seems like this topic was overlooked in this discussion. My review of some local Siberian papers indicates that it might be extremely important. Decentralization and privatization has a large impact on building and maintenance

practices in many northern cities in Russia. For example practice of centralized snow removal to sustain ground thermal regime was abandoned. Same can be said about continuous centralized geocryological monitoring of buildings. Because short time profit seems to be outweigh large investments, private developers and businesses build structures without any consideration of underlying permafrost conditions: the cost of construction plays a major role. For instances large number of cheap small kiosks, which were prime small business enterprises in Russia few years ago caused significant modification to ground thermal regime and caused significant damage to nearby permanent structures in Yakutsk.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Henry Huntington)

Posted by: *Doug Goering* at 10:41 AM 4/17/2002

Henry's question regarding how we engage permafrost scientists and engineers to study these problems in an interdisciplinary approach is a good one. I think there are many common avenues that we could explore. One thing we might do is to increase our study of "man made" terrain in addition to the natural land surface. Having better data on the effects of surface alteration (snow removal, vegetation removal, surface moisture content, etc.) on the surface energy balance would be useful. This data could be used to better predict effects on infrastructure as the climate warms. Of course, we will also need some way of 'quantifying' climate change and I agree with others here that a risk based statistical approach is probably the best. This is already common in the engineering field, i.e., designs are not based on an average thaw season, rather they are based on some sort of 50 or 100 year thaw. The main problem is that this thaw index data is historical and may not be adjusted for the effects of climate change.

Regarding Anne's comments - I think you're correct that things are changing and the Barrow Post Office may well be an example of a location where the safety factor has eroded to zero. It may also be that there is some local problem there with the design (perhaps the insulation was crushed during installation, perhaps there is some source of heat such as ponded water or a sewer line, etc.). Building anything on permafrost has always been problematic and this may be one of the reasons engineers tend not to see climate change as their biggest problem. In fact, we already have large regions of warm permafrost where there just aren't any affordable effective solutions at all. Just spend some time driving the road system in interior Alaska! Unfortunately, this zone of really problematic warm permafrost is going to expand with climate warming.

Finally, regarding Nikolay's comments about socio-economic factors - I agree whole heartedly that this can be a huge problem. Problem is that private enterprises often do not have a long-term view and may not have appropriate expertise when it comes to correct construction/design practice for permafrost areas. One way around this is through appropriate government regulation (building codes, etc.). Of course these regulations must also incorporate climatic effects, including potential change.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Nikolay Shiklomanov)

Posted by: *Henry Huntington* at 11:14 AM 4/17/2002

Great points, Nikolay. The social and economic changes and their impacts on permafrost are something I'd never thought of before, but is clearly an important area for research. One might also look at incentives for investment in industrial infrastructure--economics and profits over the short term, vs. regulatory environment and requirements for remediation, which as Larry

Hinzman has pointed out may ignore the effects of change to vegetation cover and permafrost. This seems like a rich area for research.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Doug Goering)
Posted by: *Nikolay Shiklomanov* at 12:24 PM 4/17/2002

I agree with Doug about government regulation. Russians have great experience in building in permafrost regions and permafrost-specific building codes and regulations do exist. However the problem is in implementing them. For many local and city governments it is much more important to sustain very fragile private sector than enforcing regulations which might be too costly for small businesses and politically unpopular. While they understand that it will be much more expensive at the end, Russian Arctic communities do live on the day-by-day basis trying to make ends meet. The problem of global change considered to be negligible when compared to economic and political difficulties. This attitude prevails even on federal level. Recent parliament (Duma) hearing on climate change is one example.

Post Title: Re: CLIMATE CHANGE IMPACTS ON PERMAFROST (Nikolay Shiklomanov)
Posted by: *Tom Osterkamp* at 12:59 PM 4/17/2002

The points discussed have been very pertinent and it may be worthwhile to add a few more. Historically, there are always areas of permafrost, typically near the southern margins, where most of the permafrost is very close to thawing. With climatic cooling, this permafrost will aggrade but with climatic warming this permafrost will thaw. Climate has been warming for more than a century and, coincidentally, permafrost in many areas on earth has been warming and thawing. This is consistent with observations in Alaska. These observations have defined the magnitude and approximate timing of the warming and have delineated natural areas where permafrost is currently thawing. A point of concern is that the warming and thawing appear to be accelerating at a time when global circulation models predict increased warming. Research delineating the response of permafrost to changes in climate is needed to develop better models that predict more precisely the interactions between climate and permafrost. The results would allow improved assessments of the impacts of thawing permafrost.

The warming of the last century and our subsequent observations have shown us what impacts to expect as a result of permafrost thawing. This is an important point in these discussions. We are not theorizing about what "might" happen; we have already observed the impacts of permafrost thawing on infrastructure and subsistence.

People who live on ice-rich permafrost are often made acutely aware that permafrost forms the foundation on which they live. This foundation is held together by ice and when that ice melts the foundation dissolves. When infrastructure is impacted, a frequent question is, "Was this a result of climatic warming". As Vlad points out, it is most likely due to the effect of the infrastructure on the permafrost although some portion of it must be due to climatic warming. It is hopeless to try to separate these effects.

The impacts of thawing ice-rich permafrost on infrastructure are quickly noted; however, while permafrost has been thawing for more than a century, impacts occurring in the environment and on ecosystems have hardly been noticed until recently. Quite likely, subsistence hunters and gatherers noticed the impacts but they are receiving new recognition from scientists. Over several decades, the impacts can be major resulting in the partial or total destruction of boreal forest ecosystems that are then replaced by different ecosystems. Generally, this seems

detrimental to caribou and some terrestrial animals and birds but favorable to moose and aquatic mammals and birds. Research is needed to further delineate these impacts.

Monitoring thermal conditions in permafrost provides us with information on rates and magnitudes of changes in the permafrost as well as its thermal state. Such information is necessary to determine the "health" of the permafrost, as Vlad already mentioned, and to assess potential impacts. However, this is commonly considered a monitoring activity. While this type of activity is being viewed more favorably by funding agencies, some proposal reviewers still do not consider monitoring to be mainstream science. As a result, a proposal for monitoring may have a poor rating mixed in with others making it impossible to fund. A way out of this dilemma needs to be found.

Two papers about the impacts of thawing permafrost on infrastructure and subsistence are attached [see abstract below].

Osterkamp, T. E., L. Viereck, Y. Shur, M. T. Jorgenson, C. H. Racine, A. P. Doyle, and R. D. Boone, **Observations of thermokarst in boreal forests in Alaska**, Arctic, Antarctic, and Alpine Research, 32(3), 303-315, 2000.

Abstract

Thermokarst is developing in the boreal forests of Alaska where ice-rich discontinuous permafrost is thawing. Thawing destroys the physical foundation (ice-rich soil) on which boreal forest ecosystems rest causing dramatic changes in the ecosystem. Impacts on the forest depend primarily on the type and amount of ice present in the permafrost and on drainage conditions. At sites generally underlain by ice-rich permafrost, forest ecosystems can be completely destroyed. In the Mentasta Pass area, wet sedge meadows, bogs and thermokarst ponds and lakes are replacing forests. An upland thermokarst site on the University of Alaska Campus consists of polygonal patterns of troughs and pits caused by thawing ice wedge polygons. Trees are destroyed in corresponding patterns. In the Tanana Flats, ice-rich permafrost supporting birch forests is thawing rapidly and the forests are being converted to minerotrophic floating mat fens. At this site, an estimated 84% of 2.6×10^5 ha was underlain by permafrost a century or more ago. About one half of this permafrost has partially or totally degraded and is influenced by thermokarst. Thaw subsidence at the above sites is typically 1 to 2 m with some values up to 6 m. Much of the discontinuous permafrost in Alaska is extremely warm so that it is highly susceptible to thermal degradation. Additional warming will result in the formation of new thermokarst.

HARC Online Workshops > Societal Vulnerability and Impacts > Infrastructure and Development

Post Title: Infrastructure and Development
Posted by: *Henry Huntington* at 5:18 PM 4/11/2002

Much of the infrastructure in the Arctic was designed with current (or past) conditions in mind--accounting for anticipated temperatures, winds, snow load, storm surges, flood levels and frequency, etc. Some of those conditions may have changed or be changing. Permafrost is an obvious example, where construction based on the idea that permafrost is permanent will be in trouble if the ice melts. There is some evidence of changes in construction requirements already (for example, Anne Jensen reports that piling depths in Barrow must be greater now than in the past).

One way to study this would be to look at the engineering specifications for current construction, especially in large developments like Prudhoe Bay, and compare the anticipated range of conditions with what we now see and what we predict or anticipate in the coming decades. If changing conditions fall within the tolerances to which the structures were built, and if we think the engineering is still good, all's well. If not, we can begin to identify some vulnerable areas that may include large and economically (and environmentally) important structures like those on the oil patch.

Post Title: Re: Infrastructure and Development (Henry Huntington)
Posted by: *Larry Hamilton* at 6:44 AM 4/13/2002

Henry's post mentions possible impacts of hydrological change on industrial infrastructure, such as Prudhoe Bay. Other examples include the Red Dog Mine with its haul road and port facility. Not only the production infrastructure, but the environmental-protection arrangements as well (e.g., stream re-routing, tailings and waste disposal) could show new vulnerabilities under changing conditions. Is there evidence or analysis of potential problems with any of these systems?

The other main type of infrastructure in the Arctic belongs to Arctic communities themselves. Housing, schools, fuel storage, and in larger towns airports, hospitals and administrative buildings -- all were built under hydrological regimes that might now be changing. What problems are occurring, and what adaptations are needed?

Two critical and already problematic areas for many Arctic communities are the town or village water and waste-disposal systems. How will permafrost, surface water, snow cover and precipitation changes affect community supplies of fresh water, including the costs sunk into existing systems? How will they affect waste disposal, either sewage systems or less formal arrangements? For that matter, how will hydrological changes affect the environmental and health aspects of solid-waste disposal at the community dump?

These questions address the sustainability and quality of life in the Arctic today. There seems to be wide scope and urgent need for research.

Post Title: Re: Infrastructure and Development (Larry Hamilton)
Posted by: *Larry Hinzman* at 3:00 PM 4/14/2002

Another interesting question follows with respect to water supply. Most of the villages in northern and western Alaska secure their water from surface supplies (small ponds or rivers). If the permafrost degrades to the point of forming a talik (an unfrozen zone below the depth of normal winter freeze and above the relic permafrost) those surface supplies may vanish due to internal soil drainage. How will this impact those villages? What are their possible alternatives? Is there anything that could be done to mitigate these problems before they occur?

Post Title: Re: Infrastructure and Development (Larry Hamilton)
Posted by: *Henry Huntington* at 10:19 AM 4/15/2002

One big concern many communities have expressed is increasing coastal or riverbank erosion. In some cases, managing erosion is just part of routine maintenance. In others, it's a major problem that requires drastic measures, up to and including village re-location. Many erosion-control measures, however, are evaluated on a cost-benefit basis (where small population means small benefit and hence low priority). These likely assume a static environment (i.e., no change in hydrology), and may ignore the potential for major changes that require drastic measures. How can the potential impacts of hydrological change be incorporated into planning efforts regarding erosion? I.e., can we make even a qualitative assessment of how hydrological change may lead to larger-scale problems if we do nothing to respond to current erosion? (As one example.)

Post Title: Re: Infrastructure and Development (Larry Hamilton)
Posted by: *Kenneth Johnson* at 10:24 AM 4/15/2002

Solid waste management in northern communities, particularly the smaller ones in Canada, has in many respects been neglected until the last several years. The "appropriate" technology for these communities has been burning to reduce waste volumes, and remove accumulated snow that would take up volume and hence reduce the life of the landfill site. This technology is of course undesirable, and the communities are reminded of this fact constantly by the regulators. However, appropriate alternatives for these small communities to reflect the current natural environment have not yet appeared. Appropriate alternatives to reflect a changing natural environment are well beyond the horizon for many communities.

These communities need a comprehensive base of information for solid waste management that is presented and implemented in a manner consistent with their community resources. This information should include hydrological elements, such as leachate generation. Leachate generation is a regulatory concern may have limited grounding for northern communities given the nature of the waste, the low precipitation in high arctic communities, and the limited opportunity for precipitation to infiltrate into a landfill if the offsite drainage is properly managed.

Post Title: Re: Infrastructure and Development (Henry Huntington)
Posted by: *Kenneth Johnson* at 10:46 AM 4/15/2002

Shoreline erosion, whether it be coastal or riverbank, is a problem that goes beyond any technical or economic based solution. The assets that will be impacted by this problem include churches, cemeteries, and other culturally significant landmarks - one cannot simply relocate

something that has a spiritual significance to a community. On the other hand, the costs associated with uncertain protection of these assets are prohibitive.

The solution to this problem will remain elusive until the technology and the humanity create common ground for an understanding and appreciation of each others needs, aspirations, and limitations.

Post Title: Re: Infrastructure and Development (Kenneth Johnson)
Posted by: *Larry Hamilton* at 11:14 AM 4/15/2002

Shoreline erosion is a particularly vivid problem in Kivalina, built on a gravel bar that grows narrower each year. Relocation seems unavoidable and unaffordable both. Have there been surveys of other communities facing similar dilemmas, and how acceleration of shoreline erosion (e.g., associated with reduced ice cover) might affect them?

Post Title: Re: Infrastructure and Development (Larry Hinzman)
Posted by: *Dan White* at 2:33 PM 4/15/2002

Dr. Hinzman poses some interesting questions about water supply. Certainly there should be concern about potential hydrologic changes on the quantity and quality of water supplies in the future. Most villages in the Arctic are dependent on seasonal ponds and streams for a source of drinking water. The deep permafrost prevents access to groundwater and except for a few major rivers, surface water supplies are seasonal. As such, most northern villages treat enough water in the summer to last the 6-9 month period that water supplies are dry or frozen. Even for small villages, 9 months of water equates to millions of gallons of water storage. If hydrologic changes resulted in surface water being lost through taliks, villages may lose their only water supply for all or part of the year. Even a loss of one month of the pumping season could prevent certain ponds and streams from being adequate water supplies. This isolation from ample surface water may result in relocation or use of poor quality water such as that which collects in the shallow marshy areas characteristic of the coastal plain.

Another concern about potential hydrologic changes on drinking water is the potential for cross contamination between sewage lagoons and drinking water ponds. In many river delta's (e.g., Y-K) and coastal plains, only a foot or two of topographic relief separate the sewage lagoon from the drinking water. Slight shifts in hydrologic regime may well put these waters in communication..

Post Title: Re: Infrastructure and Development (Kenneth Johnson)
Posted by: *Henry Huntington* at 2:37 PM 4/15/2002

Very good point about the limitations of what we can do to control erosion. I suppose the question then becomes, what are the likely impacts of erosion under plausible scenarios for the future, and what will have to be done? Kivalina and Shishmaref, two communities in western Alaska suffering from severe erosion, will have to move sooner or later. If this type of disaster becomes more common, society may be unwilling to bear the costs of relocation (as may already be the case for Shishmaref and Kivalina, at least for the options the communities prefer, which have more to do with hunting and fishing access than with geological and engineering suitability). The responding agencies (Army Corps of Engineers, Federal Emergency Management Agency, etc. in the US) may need to start thinking about this kind of thing, if they aren't already.

Post Title: Re: Infrastructure and Development (Kenneth Johnson)
Posted by: *Dan White* at 2:47 PM 4/15/2002

At many solid waste dump sites in small Arctic communities the waste is not segregated and may contain hazardous materials, liquids, sewage and solid waste. Although segregation of these wastes is attempted, many landfills I've visited have elements of each. Potential hydrologic shifts may have a significant impact on the threat landfills pose to human health. Hydrologic shifts may result in the deterioration of permafrost, allowing contaminants to flow in subsurface talik or cause the erosion of dumpsites. I have visited river sites and ocean sites where landfills are being eroded into the river or ocean. This direct input of waste poses a significant threat to humans who use the river for drinking water or subsistence. Although people and structures may be relocated as part of a community plan in response to erosion, the landfill would likely remain and will pose a concern for long-term human and ecological health.

Post Title: Re: Infrastructure and Development (Henry Huntington)
Posted by: *Kenneth Johnson* at 4:01 PM 4/15/2002

Tuktoyaktuk is another good example of a coastal erosion progression with a community impact. A study has just been completed for the GNWT which took a new view on the problem by quantifying the erosion progression (best guesstimates) and putting this into the context of community impact. The progression was presented in increments of 10 and 25 years, and simply presented on a community map showing what buildings would be "impacted". To parallel the erosion progression, an evaluation of the buildings was made to develop a physical rating of each structure (age, ownership, condition, use, etc).

The intent of the study was to provide a less technical perspective on the problem, and possibly change the direction of the community action, which in simple terms is protection the shore regardless of cost.

Post Title: Re: Infrastructure and Development (Kenneth Johnson)
Posted by: *Henry Huntington* at 4:59 PM 4/15/2002

Another excellent point about the community preference often disregarding cost--"Keep the beach from eroding" when nothing can do that. The presentation of likely impacts over time is one way to give information without the implied valuation that the response options include. I.e., "in 10 years we think the beach front will be here" is vastly different from "you should move these buildings over there."

One aspect of research in this field could be the development of community response options and the process of making informed decisions within existing constraints (cost, geology, etc.). I'm sure there has been research on this type of decision making, but I wonder if it's been applied in this context?

Post Title: Re: Infrastructure and Development (Henry Huntington)
Posted by: *Larry Hamilton* at 6:43 AM 4/16/2002

North American Arctic communities are very old and very new. On my first visit to Ambler, I was fascinated to see that the school's trophy case displayed 13,000-year-old artifacts alongside recent athletic awards. People have lived in that neighborhood for a very long time. But the

modern fixed settlements with hundreds or thousands of people, and all the infrastructure and byproducts of modern life, face new problems in this environment which could be exacerbated by hydrological change. Comments by Kenneth Johnson and Dan White about water supplies and waste disposal, or by Julie Sprott, Henry Huntington and others about shoreline erosion, illustrate the complexities -- social as well as engineering/planning -- of making Arctic "cities" truly sustainable.

Kenneth mentions the need for (and absence of) "appropriate technology" applied to Arctic community waste issues. Do the difficulties ahead provide an opportunity as well as a more urgent reason to rethink how things are done? And how do the political divisions that Julie mentions (and which I've seen extended to issues about water systems as well) affect the process of stakeholder participation in planning?

Post Title: Re: Infrastructure and Development (Dan White)

Posted by: *afarris* at 9:51 AM 4/16/2002

I think it is good comment about contaminant transport from village waste disposal areas, but there are additional disposal areas that may have large contaminant concerns. I work on environmental cleanups of the former DEW Line installations that the military built in the 1950's. Each of these installations has at least one dump site, typically there is more than one, and they almost always are built directly adjacent to the Beaufort Sea or a large lagoon. These dump sites were completely unregulated and the installations did not keep records of what they dumped. The political will is not there to force excavation of this old dump sites because of the large initial expense and safety concerns. Instead, erosion control is relied on to keep these dumps in place and hopefully prevent hazardous chemicals from leaching into the ocean. In choosing erosion control as a remedy, however, the risks and economics of long-term maintenance is not accurately accounted for, particularly in light of a significant change in erosion rates. The long-term costs and risks of controlling these dump sites, instead of removing them, have to be thoroughly evaluated in order to make better risk management decisions.

Post Title: Re: Infrastructure and Development (*afarris*)

Posted by: *Larry Hinzman* at 10:09 AM 4/16/2002

Thanks for bringing these abandoned DEW line sites into the discussion Ann. This is an important topic that needs to be brought to the attention of the scientific community. Nothing can be done to restore these sites until the political will (more appropriately, huge amounts of money) is there, but perhaps informing people who want to do contaminant studies is the first step. If significant leaching can be demonstrated or if a significant hazard to population centers is identified, then something may be done.

Post Title: Re: Infrastructure and Development (*afarris*)

Posted by: *Dan White* at 10:59 AM 4/16/2002

Good point about the DEW line sites Ann. Having seen many of them I agree that they pose a threat. In addition, most sites have unrestricted access. Many of the sites are presently inundated from erosion or inundation is imminent. Are there any erosion control measures that you have seen that were successful? Coastal erosion in areas of ice-rich permafrost is very aggressive. I can't imagine an erosion control strategy that would protect some of these sites. What do you think?

Post Title: Re: Infrastructure and Development (Larry Hinzman)
Posted by: *Kenneth Johnson* at 11:19 AM 4/16/2002

The Dew Line Cleanups represent the ideal model for site remediation in cold regions, but this model is beyond the means of northern communities. The reality of the "devolution" of financial and administrative responsibilities from senior governments to the communities has meant freedom of choice by the communities, but with significantly less funds. A classic example for me is Tuktoyaktuk, where borrow material costs in excess of \$40 per cubic metre, and for this price one can easily see why the community chooses to use this material to maintain their roads rather than cover their landfill.

Post Title: Re: Infrastructure and Development (Dan White)
Posted by: *afarris* at 1:38 PM 4/16/2002

The Air Force installed an extensive (and expensive) groin system at Barter Island, which appears to be working so far. It has only been in place for 2-3 years, though, and they have already needed to do maintenance. In addition, the erosion rates at Barter Island do not seem to be as high as I have seen at other locations. Oliktok Pt. is another site I'm working with that seems particularly vulnerable and I really don't believe any erosion control methods will work there.

I think the other side of this is brought up by Kenneth, which I think boils down to where do we allocate the available resources. Whether it is gravel or money or something else, are these dump sites a big enough concern to take priority over other issues? I don't think the information is there to completely quantify the risk from these sites so I find it a difficult question to answer. Currently, these management decisions are primarily being decided by upfront costs, which may be short-sighted.

Post Title: Re: Infrastructure and Development (Henry Huntington)
Posted by: *ffjam* at 3:01 PM 4/16/2002

Henry's comment about changes in construction requirements is of interest both with respect to industry practice and permitting requirements. For example, during the permitting process for BP's Northstar development, environmental organizations focused on the subsea pipeline. They contended it would not withstand anticipated large ice overrides, ice gouging, and strudel scour. For these reasons, they requested that BP install a double-walled pipe. BP's response was that this was not yet industry practice and that the anticipated conditions fell within existing design tolerances. The permitting agencies did not challenge this, based on data largely supplied by industry.

HARC Online Workshops > Societal Vulnerability and Impacts > Self-purification processes in Arctic Seas: Relationships between terrestrial and coastal microbial

Post Title: Self-purification processes in Arctic Seas: Relationships between terrestrial and coastal microbial

Posted by: *Vladimir* at 11:30 PM 4/14/2002

Dear Colleagues,

as you know, a lot of pollutions enter to the Arctic Seas with river's and coastal effluents. All these pollutions than become a subject of self purification processes with participation of different marine and terrestrial microorganisms. We have a real data, that a lot of oil-degrading microorganisms in coastal regions have a terrestrial origin. We are interesting, what are the differences in their biochemical properties and activities in coastal soils and coastal waters with special attention to oil biodegradation processes. As the final stage we plan to prepare a map of microbial diversities and activities for our observations areas with using precise positions for every samples location (satellite navigation). A special attention we have to oil-biodegradation processes, because these data may be use than for estimation of real self-purification abilities from oil pollution for coastal Arctic regions. These data, as we think, may be use for ecological monitoring, because some of the Arctic coastal areas have a great oil stocks and may be use for oil recovery in the near future.

I have a great troubles about the future of ecological investigations in Russia. We have a very small government support for these works and as result we need to stop our investigations for a long time to search a new source of money. As you know, ecological investigations in polar regions are very expensive. I tried to find any foreign grants, but have no success, because NSF grants are only for US-citizens, for example and I can't find any international grants for polar scientists. I tried to find cooperation with US polar microbiologists from Alaska University, for example, but they have a lot of own grants and have no interests for cooperation and new grants searching. I really understand, that near impossible to find foreign scientists for cooperation, if you have only e-mail connections and have no financial possibilities for travel to the International Meetings for direct contacts "face to face".

As I think, it may be a good to have a special international fund for Arctic scientific cooperation. Its may be a good than to have some special scientific centres with modern equipments for joint training. As I know, such centre was recently organize in Vladivostok with help of Alaska University. It will be a good to have the same centres in other parts of Russia with big student's communities - in Moscow and St.. Petersburg, for example.

As I think, Arctic Seas pollution may be a great ecological problem in the nearest future and we can manage this problems only together.

I shall be glad to have any advices from you, dear colleagues. I will be greatly appreciate for any information about the international grants for Polar Investigations too.

I am very sorry for my bad English.

With respect,
Vladimir.

HARC Online Workshops > Implications of Hydrologic Change > Land Use Planning and Climate Change

Post Title: Land Use Planning and Climate Change
Posted by: *Kenneth Johnson* at 9:42 AM 4/11/2002

The various impacts of climate change on community planning in the Canadian Arctic include loss of land, flooding, and all of the associated public health and safety issues. The regional land-use impacts will influence renewable resources (forestry, fish and wildlife), non-renewable resources (mining), and transportation (marine, all-weather roads and ice roads). The effects are wide-ranging, from changes to the renewable resource aspect of the polar bear habitat to the transportation issues arising from a Northwest Passage that is navigable year-round. Such impacts will also influence community planning, as seen in the community of Tuktoyaktuk, Northwest Territories.

Post Title: Re: Land Use Planning and Climate Change (Kenneth Johnson)
Posted by: *Henry Huntington* at 11:18 AM 4/15/2002

I'm curious how these matters are incorporated in community planning. Many of the potential changes are hard to quantify or predict, even if we know things are unlikely to stay the same. How does the planning effort incorporate uncertainty about future climate and its impacts?

Post Title: Re: Land Use Planning and Climate Change (Kenneth Johnson)
Posted by: *Lilian Alessa* at 1:47 PM 4/15/2002

Does community planning extend to where and how food resources will be obtained? Can we address regional planning here?

Post Title: Re: Land Use Planning and Climate Change (Lilian Alessa)
Posted by: *Henry Huntington* at 2:44 PM 4/15/2002

Yes, Lil, on both counts! Give us your ideas!!!

Post Title: Re: Land Use Planning and Climate Change (Henry Huntington)
Posted by: *Kenneth Johnson* at 3:10 PM 4/15/2002

Community planning in the north has only acknowledged the fact that climate change may have an impact on communities. This acknowledgment may in fact be the key ingredient to incorporating climate change action into community planning because it validates discussion at the community level, and the senior government level, and may demand particular considerations in response to discussions, particularly at the community level. Community planning by its very nature is a dynamic process, but it must have the appropriate sheparding to maintain a realistic and useful path.

Post Title: Re: Land Use Planning and Climate Change (Kenneth Johnson)
Posted by: *Larry Hinzman* at 5:04 PM 4/15/2002

Often, changes that result from infrastructure development overwhelm the natural environment much more than the subtle signal from a change in climate. For example, construction of a road, building or parking lot may change the average annual temperature by 20 degrees, while we

may only see an increase of a few degrees in the air temperature over 100 years as a result of increasing green house gases in the atmosphere. Building one major dam on a large river can change the annual river outflow hydrograph much more than would ever occur from climate warming. These are examples of global change and they too can feedback to have substantial impacts on the arctic system. Given these differences in scale of impacts, is it surprising that communities do not place much importance on a changing climate?

Post Title: Re: Land Use Planning and Climate Change (Larry Hinzman)

Posted by: *Lilian Alessa* at 7:04 PM 4/15/2002

Are large scales (in the arctic) considered the total (physical) "mosaic"? What about the discrete (functional) units of the mosaic? If humans co-localize with productive (and relatively biologically dynamic but physically stable) areas, shouldn't we consider anthropogenic inputs independently within these "units" and then look at how the units are related to each other?

I think it's important that we think of the arc sys as a mosaic, especially for land use planning. Then we consider where the high productivity/output areas converge with human communities or use. This will give us (at least) a starting point for managing use allocations and designing monitoring and experiments that help us understand where climate change may have the greatest impact both on the system (as a contribution to a Body of Knowledge) and on specific locales (data that helps steer short-term reaction, i.e., application). Change occurs as part of any system and is incorporated into its large-scale spatiotemporal evolution. However, change that occurs inherently and that which is effected by anthropogenic inputs may act synergistically or antagonistically (important to remember the latter). It's the net outputs in areas where people have settled (or that are off-used) that coincide with the hotspots which may change with the greatest magnitude and frequency and, potentially, drive the overall system.

As long as we remember that infrastructure is not a solely physical process, it also includes a collective cognitive evolution. For e.g., communities which incorporate climate change (CC) into future planning should also consider planning for behavioural changes that may need direction and facilitation. These can include (for e.g.,) understanding how humans perceive and respond to uncertain futures, how this uncertainty influences their expectations (both from themselves and their surroundings), how these expectations become behaviours. Just as physical hotspots are more affected by CC, so, perhaps are social "hotspots". We need to understand what these are, specifically, in order to understand how perceptions and expectations may affect decision-making for land use planning.

Post Title: Re: Land Use Planning and Climate Change (Lilian Alessa)

Posted by: *Larry Hinzman* at 11:04 PM 4/15/2002

This is a great contribution Lilian. The impacts to society are not just engineering designs of infrastructure or physical studies of permafrost degradation. Understanding changes in perceptions and predicting changes in behavior are important questions that will impact our society. An important aspect of this forum is to define how we could quantify these? What research could be done to characterize these aspects of human vulnerability that can not be measured with a thermometer or a strain gage? What are those most pressing research problems? What are the priorities? How can a study be designed to predict human responses to environmental change?

Post Title: Re: Land Use Planning and Climate Change (Larry Hinzman)
Posted by: *Kenneth Johnson* at 8:39 AM 4/16/2002

At the community level climate change has been observed and recognized, but more in a context of TEK (traditional environmental knowledge), and not the scientific context of "outsiders". TEK is certainly being incorporated more often in science, but it has reached into the realm of planning or engineering.

The full integration of TEK may not come until a strong base of aboriginal scientists, planners and engineers is working on cold region technologies.

Post Title: Re: Land Use Planning and Climate Change (Kenneth Johnson)
Posted by: *Christy Miller* at 9:43 AM 4/16/2002

Interesting discussion. I'm a planner/floodplain manager for the State of Alaska and am constantly challenged by the dire erosion threats to many of our communities. The cost and complexities of both the engineering "solutions" and social impacts of erosion on rural communities beg for better planning, but some basic data and research is often missing on which to base sound community decisions.

quote:

At the community level climate change has been observed and recognized, but more in a context of TEK (traditional environmental knowledge), and not the scientific context of "outsiders". TEK is certainly being incorporated more often in science, but it has reached into the realm of planning or engineering.

The full integration of TEK may not come until a strong base of aboriginal scientists, planners and engineers is working on cold region technologies.

Post Title: Re: Land Use Planning and Climate Change (Christy Miller)
Posted by: *Henry Huntington* at 10:24 AM 4/16/2002

I'm particularly impressed by this discussion, because I think we're beginning to look at both the social and natural systems as dynamic. Lil's mention of the importance of perception is critical--one example is whether the Arctic is regarded as stable, and thus changes are a recent anthropogenic disturbance for which "someone" is responsible, or whether it is regarded as dynamic, in which case change is normal and our mistake in much construction is to forget that fact.

The question of floodplain and erosion planning is critical. Are there examples of a community involvement process that seems to work, in terms of developing solutions that are technically and financially feasible while also responding to the social concerns of the community? And for Christy in your role as a manager, can you think of specific research topics and projects that could help your work, for example by providing a better foundation for community decisions?

Post Title: Re: Land Use Planning and Climate Change (Larry Hinzman)
Posted by: *Lilian Alessa* at 11:15 AM 4/16/2002

How about beginning with a Map. I'll simplify it for purposes of brevity.

What we could do (and it shouldn't be too hard) is:

- a) agree on biophysical criteria for 'hotspots' in the arctic mosaic (i.e., define),
- b) map them as a compilation of existing (?) layers or those that we develop from existing data (this could be done as a GIS framework in ArcView or similar),
- c) compile, map and layer demographic and use data (many of these exist from state, state and federal agencies....there are also many many gaps as I'm finding out),
- d) determine where the overlaps between social and physical systems occur in the overall system.

What we would end up with is

- a) an idea of where the hotspots are based on our agreed criteria and
- b) where the biophysical hotspots intersect with human activities.

(i.e., the convergence hotspots)

Most likely this will be a majority overlap scenario where there are gradients of "hotspottedness" but also one which will clearly show us those convergence points.

We can then look at each of the hotspot domains (the tiles in the mosaic) and proceed to collect details on the communities/societies involved in the interactions within each hotspot.

I'll have to clarify this but don't want to run on (as usual).

So within each hotspot we'll be able to address the following:

- a) what are the use allocations within each comm/society (i.e., based on biophysical interactions)?,
- b) what are the human activities that could feed back into the biophys sys?,
- c) what cultural domains exist within the comm/society? (this is a first step in understanding potential social hotspots and a set(s) of attitudes, perceptions, preferences and behaviours)

Between each hotspot we'll be able to understand which could potentially influence other hotspots via physical (e.g., rivers) or biological corridors (or vectors) and what are the temporal components (that's not the right word.....) such as mobile and seasonal animal herds like caribou or whales.

Are most of these data already available? If so, it would be an exercise in organizing it so we can view the mosaic and determine where the social systems intersect the physical systems.

Perhaps this would be a good starting point?

(Does anyone have a better word than 'hotspot'....)

Post Title: Re: Land Use Planning and Climate Change (Lilian Alessa)
Posted by: *Dan White* at 11:32 AM 4/16/2002

This is a good strategy Lil. There is some overlap between this discussion and that going on in "Infrastructure and Development". Since many of the contaminated sites on the slope (and elsewhere in AK) are not well documented, I believe getting these in an overlay with human use areas will be eye opening. For example, significant erosion is occurring at DEW line sites. Many of these sites are contaminated with organic and inorganic contaminants. Although the DOD has records on the DEW line sites, this data is not detected on the same radar screen as subsistence use patterns. Geese that fly by Nuiqsut may well have spent some time at a contaminated site not so far away. Climate change is likely to exacerbate the threat posed by contaminated sites as potentially shifting hydrologic patterns liberate contaminants. While land use planning can prevent humans from visiting known contaminated sites, we really must be evaluating the changing land use on an ecosystem level.

Post Title: Re: Land Use Planning and Climate Change (Lilian Alessa)
Posted by: *Kenneth Johnson* at 11:37 AM 4/16/2002

The "map" of "critical geography" is what would best serve the dialogue between the various stakeholders (community, government, researchers, business, etc.). A key element to this map would be the development and agreement on the criteria of the presentations or layers. As well, the level of detail (regional areas versus community areas) would have to be considered. Regional and community related presentations are quite often incompatible because of their relative level of detail.

Post Title: Re: Land Use Planning and Climate Change (Lilian Alessa)
Posted by: *Dan White* at 11:48 AM 4/16/2002

A discussion is on-going in Infrastructure and Development about water supply quality. An important component of an ecosystem approach is consideration of the availability of an adequate water supply. As I am sure you know, most villages in the Arctic are dependent on seasonal ponds and streams for a source of drinking water. The deep permafrost prevents access to groundwater and except for a few major rivers, surface water supplies are seasonal. As such, most northern villages treat enough water in the summer to last the 6-9 month period that water supplies are dry or frozen. Even for small villages, 9 months of water equates to millions of gallons of water storage. If hydrologic changes resulted in surface water being lost through taliks, villages may lose their only water supply for all or part of the year. Even a loss of one month of the pumping season could prevent certain ponds and streams from being adequate water supplies. This isolation from ample surface water may result in relocation or use of poor quality water such as that which collects in the shallow marshy areas characteristic of the coastal plain.

I would think that in the GIS map we would want to include where water supplies are threatened by climate induced changes, both in terms of quantity and quality.

Post Title: Re: Land Use Planning and Climate Change (Dan White)
Posted by: *Lilian Alessa* at 5:50 PM 4/16/2002

So? What's the feeling on the availability of these data as per status quo? High? Moderate? Low?

Can we agree on some criteria that reflect not only the "critical geography" but also the dynamism of the biophysical and social system?

If so, we can accomplish this goal in reasonable time and then look at the hotspots themselves (as per Larry Hinzman's queries).

Post Title: Re: Land Use Planning and Climate Change (Dan White)
Posted by: *Kenneth Johnson* at 8:46 PM 4/16/2002

The potential impact of water supply shortages is already evident in several northern Canadian communities, although climate change may not be the contributing factor.

In the community Gjoa Haven on the central arctic coast, the community was seriously considering the construction of a reverse osmosis (RO) water treatment plant to treat sea water for the community's water supply. The capital cost for this system is over \$4 million (Canadian) for a community of less than 1000 people, and the operation and maintenance cost would create a considerably larger life cycle cost. These costs do not take into account the community's ability to maintain the operation of a reasonably complex mechanical system. Fortunately the RO option was reconsidered, and a pipeline to a new freshwater lake was selected as the most appropriate solution.

In the community of Tuktoyaktuk, the water level community's seasonal supply lake has been dropping over the past several years, and is creating a concerns with water quality, and water quantity for the resupply of their reservoir.

Complete community relocation in response to water supply, or other infrastructure problems is almost out of the question in Canada. Communities such as Inuvik (built to replace Aklavik) and Edzo (built to replace Rae) in the NWT were created based upon a perceived need to provide a "better" community location. In both cases the original community is still thriving. A current example of a northern community relocation is Davis Inlet in Labrador, which is being relocated to a new townsite for a cost of over \$100 million (Canadian) for a current population of approximately 600 people. The people have not yet relocated to the new townsite since the construction is not yet complete.

Post Title: Re: Land Use Planning and Climate Change (Lilian Alessa)
Posted by: *Alexey Voinov* at 9:50 AM 4/17/2002

Just learned about the workshop yesterday, so still trying to catch up with the discussion.

I like the idea of mapping hotspots. Two concerns in this regard:

1. A definition of a hotspot will always have a value connotation, it will be always value driven. What's hot for me can be cool for somebody else. Even a "biophysical" hotspot is not neutral or objective. Even more so with social hotspots. A hotspot will always have a spatial implication (what's hot on a local scale may be insignificant on a regional scale) as well as a temporal one (what we consider hot today, was totally OK yesterday and vice versa). Therefore I would suggest that before we really start collecting and assembling the GIS data, we first define exactly what is our particular goal and where are the boundaries of this study. Otherwise this data set may become overwhelming, and should include just everything.

2. There has been several mentions of dynamics and dynamism. However GIS are still pretty much static. They work well to save and process the snapshots, but they offer very limited functionality to describe the pathway from one snapshot to another. But in many cases it's in the dynamics between states where the problem ("hotspotedness") manifests itself. To my mind that is where modeling and especially spatial modeling can be of great value. In that case we document the processes in addition to states. This dynamism is actually what makes the whole thing especially exciting, since the definition of a hotspot may be also changing in time. As a result you may end up with totally different coverages than you thought you would need to describe the hotspots.

And that's where one other attribute of the hydrologic cycle seems to come into play. In addition to water quantity and quality, this cycle serves as a means of spatial transport. It is water, both in the air and on the land, which is essential to move around numerous constituents, linking together different localities, purifying or polluting individual sites. Therefore disruptions of this transport mechanism (in any scale) may have long-lasting consequences. Once again we need good spatial models that would reproduce this dynamism.

I would argue that there are probably just three mechanisms that accomplish this transport function: the air dynamics (to move dust), the hydro cycle (which would link with the air cycle to move vapor) and the human cycle (whatever that means). One could think of large migrations of animals, but those move only their own biomass, whereas the air, water and humans move other stuff. Therefore if we are talking about planning it seems to be essential to see how the human transport of energy and materials co-mingles with the hydrologic transport. And again I can't see how to do it without spatial models of both.

Post Title: Re: Land Use Planning and Climate Change (Alexey Voinov)
Posted by: *Lilian Alessa* at 10:55 AM 4/17/2002

With respect to the value designation of a 'hotspot'. I think we can minimize this by pulling in relatively objective data which indicate productivity, etc. It's the definition of "What's Productive?" that requires some standardization but this can still be formed to a systematic process. So, yes, there are value statements but remember that value statements often exist even in our western science method, as overt (as in "These data suggest the system is recovering.....deteriorating" or "Loss of biodiversity reduces ecosystem resiliency" as opposed to "The system is changing") to embedded (as in "a positive or negative result" as opposed to "a result"..... In each of these statements, ideally there are specific and carefully considered definitions and agreements of what each word means (or there should be, as we know there is also significant drift in our scientific language). Entire research projects may be based on reviewers' value statements...but this is a topic for discussion in another string.

Your point of spatial relativity is a good one and imp. That's why we need to consider both the interactions between and within these purported hotspots. The argument being that 'within' is a smaller (local) scale and the 'between' is a larger (regional) scale. This also brings us back to cultural domains which can be highly spatially segregated.

I'll be bold here and state that I don't think the data would be overwhelming if we clearly stated what we want to include. I say this because we're currently doing a small scale of this on the Kenai penin. Granted, it took almost a year to agree on which data were indicative of what but we did arrive there and I would hazard to say that, so far, the data look good but that's a value statement, too! (<Big smile>).

With respect to the use of GIS, this is simply a means to a visualization process which is needed in order to start. In terms of the ability to construct dynamic interactions, it is not an end. And it's important that you remind us of that. Modeling is at least one of the proposed outcomes (ends).

In general (not in this forum), and with respect to both modeling and the "human cycle", one of the arguments that is used to justify remaining disengaged with human dimensions research is that humans are just too unpredictable.

I disagree.

I think human behaviour is highly variable but I think cognitive responses, which after a certain critical mass of people engaging in them become social normative behaviour, are predictable enough to model. However, the data required to do this (the analogy would be buoy data collected throughout the arctic system) do not exist. The data we're collecting in the Kenai are on a small scale and we were limited by the budget in terms of going as deep as I would like to into cognitive processing. This latter component requires ongoing engagement with the communities simultaneously (v. imp, because of pre-disposing variables, for e.g., what was on the news that a.m. to what season it is!).

I think we can model human responses to uncertainty. Even more so if this is constrained to an issue such as water. I think your mention, Alexey, of the spatial components is very pertinent to this.

Post Title: Re: Land Use Planning and Climate Change (Lilian Alessa)

Posted by: *Dan White* at 11:24 AM 4/17/2002

In response to Lil's question, I believe Dr. Kara Nance at UAF maintains a GIS system that layers research data on contaminants. I don't know the extent of this database but it would be a good place to start. What are the important inputs?

Seems a good place to start is to characterize important sources, pathways and receptors.

On receptors - what are the human land use patterns today? In what ways can we incorporate TEK to learn how Arctic residents have responded to changes in the past (e.g., climate, hydrologic, ecological)? What important economic/ecological changes do we expect to be forcing functions for human land use in the future?

On pathways - what are the important biological vectors? How will the vectors respond to a changing climate? What physical transport vectors will change? Hydrology? Atmospheric deposition? Will humans be able to respond to the changing biological vectors of contaminants. What if important subsistence foods become stores of contaminants due to increased exposure of the plants/animals to contaminants?

On sources - what sources exist? which threaten humans today? will they be the same in a changing climate? I suspect a different set of sources will threaten humans in the arctic in a warmer environment. For example, while contaminants in frozen landfills are little threat today, inundation of landfills due to a changing hydrology will result in a new source....

Current and future hotspots will show up in the overlap of sources, pathways and receptors. How might we predict future human and ecological land use patterns?

Post Title: Re: Land Use Planning and Climate Change (Lilian Alessa)
Posted by: *Henry Huntington* at 11:27 AM 4/17/2002

This discussion seems to me a critical one for coming to grips with how we incorporate human dimensions into our studies. Alexey and Lilian make very good points, and I think the recognition that both social and natural systems are dynamic, and that they each have different properties depending on scale, is important to recognize. Thus, when we think about how to set up the spatial and temporal models, we need to avoid searching for simple areas of interaction that operate together, but consider the complex nature of both systems and the differences in scale, etc. Thus, as Alexey points out, we need to be careful in how we frame the study, so that we define what we mean by hot spots, over what scale, from whose perspective, etc. Lil is right that we need to recognize explicitly our biases in this regard, so that we can take them into account. These are not trivial undertakings, but I think this approach is heading in the right direction in terms of addressing the way things actually work rather than a simplified model that doesn't, in the end, tell us much. It may take some trial and error, but as I see it, the Human Dimensions field is in the exploratory phase, and we should be willing to try new things, rather than just relying on what we already know (which I think we all recognize is often not too much!).

Post Title: Re: Land Use Planning and Climate Change (Henry Huntington)
Posted by: *aeklene* at 12:40 PM 4/17/2002

In response to Alexey and Lilian I think that scale and data availability are critical issues here. There is going to be a different scale for each type of "hotspot" someone is interested in. There are examples of active work with GIS on local and circumpolar levels to look at planning issues. For instance, the North Slope Borough GIS office has a ton of different data layers in their GIS and they use those in their planning process all the time. They've incorporated cultural features and heritage sites as well as utilities and, I assume, information about hazardous material sites. At the other end of the spectrum, Nelson et al. wrote a paper (Subsidence risk from thawing permafrost. 2001, Nature, Vol. 410, 889-890.) that looked at a subsidence hazard index and infrastructure in permafrost regions. There are examples out there that we should learn from.

I think the trick here is how do we get communities the technology, know-how, and cash to apply this kind of approach to their planning needs? How can we raise awareness of the fact that baseline conditions may be changing? And how do we help communities know which factors are most important for them to consider for their own situation?

Post Title: Re: Land Use Planning and Climate Change (Henry Huntington)
Posted by: *Alexey Voinov* at 12:54 PM 4/17/2002

Yes, Henry, that is exactly the point.

It's interesting to note that each of us comes with his/her own perception based on the development stage of a particular project. Lilian et al. spent a year on a "small scale" project on the Kenai penin. Now she has a pretty good idea of what needs to be done for that area, what are the hotspots there. Apparently she is now ready to do the mapping and assemble the data. I come with my perspective from a regional study on the Imandra watershed in the Kola peninsula, where we have such a mix of scales (spatial, temporal and structural), that even after

a one year I don't feel myself in a position to clearly identify the exact goals and boundaries for the whole study. What's clear is that it has to be a hierarchy of tasks. If we can really link them together in a hierarchical framework - perfect. If not, we'll have to end up with a serious of data sets and models that will apply to certain components of the system. The linkage between them will then still remain a challenge for future efforts.

This is certainly an interactive process, but I would be very careful describing exact structures and lists of data and models, with no reference to the exact study that they apply to. I think that Dan presented a very relevant and important list of factors: receptors, pathways, sources. But before I go any further in describing and identifying them I need to figure what exactly is my goal and where are the limits of my analysis.

To Lilian on values: Of course values will be always implied. It's just important to remember about that when we try to come up with our definitions. This means that these values can change overnight, and our hotspots will follow. Starting right from where you are saying: "we can minimize this by pulling in relatively objective data which indicate productivity, etc." - Do you mean biological productivity of economic productivity? ;-)

I also agree that human behavior is quite predictable, even more predictable than we might want it to be. Certainly more predictable than weather.

Post Title: Re: Land Use Planning and Climate Change (aeklene)

Posted by: *Kenneth Johnson* at 3:00 PM 4/17/2002

quote:

how do we get communities the technology, know-how, and cash to apply this kind of approach to their planning needs? How can we raise awareness of the fact that baseline conditions may be changing? And how do we help communities know which factors are most important for them to consider for their own situation?

Another important factor is how do we convey the usefulness of this information to the community in order to gain their "buy in". Without this initial and sustained community involvement, any study will ultimately fall short of a practical application. As redundant as it may sound, community planning must ultimately serve the community for their short term and long term needs, and aspirations.

Post Title: Re: Land Use Planning and Climate Change (aeklene)

Posted by: *Anne Jensen* at 3:08 PM 4/17/2002

It is true that some places, like the NSB, do have quite a bit of data on all sorts of things. However, municipal GIS systems are generally set up and run for planning purposes. I know NSB GIS has had some real problems figuring out how to represent things that do not have discrete or unchanging boundaries (like areas where caribou are hunted as opposed to where particular caribou are killed). In addition, there is no time dimension to the layers (always a problem for GIS) so that for example, all archaeological sites are shown on one layer, with no information as to whether one is looking at something the age of the Mesa site or an early 1900s reindeer corral. It is also the case that the data gaps, especially for certain time periods, are huge. The cultural resource information is mostly used in practice to avoid direct damage to

known sites. I have argued that "hotspots" or critical human habitat areas change through time as conditions change, and that planning to avoid impacts on today's critical areas won't matter too much in the long run if the impact is merely shunted to areas that will be the critical one in 200 years (or whatever). I've suggested that while predictive modeling that worked would be nice, in the meantime using archaeological sites could give some idea of what the past range of variation in locations of critical areas has been. So far this doesn't seem to really resonate with planners.

Yet I think time is a very important dimension when trying to look at the "natural" and "social" systems (I really don't like the implication that social systems are un-natural or apart from nature--people are embedded in the natural world, however buffered we currently may be). If you don't look at things in a diachronic sense, the whole dynamic nature of the systems and their interrelatedness can be lost.

Post Title: Re: Land Use Planning and Climate Change (Alexey Voinov)
Posted by: *Anne Jensen* at 3:47 PM 4/17/2002

Alexey points out the major issue of appropriate scales. Good cultural materialist that I am, it seems one potentially productive route (not necessarily the only one) is to start on a local scale (as Lil is doing). People live locally, not regionally, and interactions with the environment take place at local . Those are the things people seem to base decisions of where to live or travel to on. As one gains understanding of the local situations, regional connections will rear their ugly heads and one may be better positioned to understand what one is seeing.

Another good point raised is what is meant by productivity? I would suggest that what resources are critical is a culturally derived thing, and what are critical habitat areas depends on that. Those areas would tend to be where the important resource(s) are both available and accessible. Changes in the environment may change availability or accessibility or both, and humans then adjust in some fashion. Complicating the situation is the fact that invention/adoption of new technology and/or new behavior patterns may change one or both of those factors (e.g. snowmobiles, fur trapping, compulsory schooling). Important resources may be prey species, but they can also be access to raw materials (like wood, jade or lead), or to good trapping territory, or a trading post. Settlement patterns at any given time may develop more in consideration of access to limited but critical resources than abundant ones, so that biological "hotspots" may not have settlements right there if some important item is lacking. Additional complications arise from inter-group issues such as warfare and trade, so that fairly rich areas lying between two powerful existing communities may not have or keep settlements of a size you would otherwise expect. As you add contact with groups from outside the region you have settlements in response to trading posts, or towns like Wainwright which is where it is rather than further up the coast (where they still usually whale) because that is where the ship unloaded the materials for the school one year. Icy Cape is still a pretty rich area in terms of hunting, but permanent settlement there was abandoned due to silting (ships couldn't get anywhere near to off-load goods, and eventually even umiaqs had to be dragged over a huge distance through shoals. More modern cases include places like Prudhoe Bay, where oil is the critical resource. It is available and accessible through current technology. There isn't much naturally occurring human food in the vicinity, but technology has overcome that.

Post Title: Re: Land Use Planning and Climate Change (Anne Jensen)
Posted by: *Lilian Alessa* at 3:56 PM 4/17/2002

Sorry, very quick one here.
With respect to scales and how people interact with the natural environment....

This goes back to my suggestion that we look at the tiles within the mosaic and then see how they fit together to give us the frieze.

Shall we begin?

Post Title: Re: Land Use Planning and Climate Change (Kenneth Johnson)
Posted by: *Alexey Voinov* at 5:35 PM 4/17/2002

quote:

how do we get communities the technology, know-how, and cash to apply this kind of approach to their planning needs? How can we raise awareness of the fact that baseline conditions may be changing? And how do we help communities know which factors are most important for them to consider for their own situation?

Another important factor is how do we convey the usefulness of this information to the community in order to gain their "buy in". Without this initial and sustained community involvement, any study will ultimately fall short of a practical application. As redundant as it may sound, community planning must ultimately serve the community for their short term and long term needs, and aspirations.

One approach that we are experimenting with is what is called 'participatory modeling'. The idea is that we start building our models with the communities being involved from step one. They don't really have to (and will hardly ever) really sit with you at the computer, but if you go to them and start asking them questions about what they think is important and then start showing them how their concepts gradually start turning into something that runs on the computer, that can actually explain some relations and produce some trends - then they start listening and feel themselves more involved in the process and consequently the results. I keep saying that when you build models the process is more important than the result. It's really the modeling process when you establish the links between data sources, the community and the researchers, and create the interaction between them, that is most important. Models are always wrong, but if we have this interaction established then we have the tools to adjust to the changing world and to work out appropriate adaptive management strategies.

Post Title: Re: Land Use Planning and Climate Change (Anne Jensen)
Posted by: *Alexey Voinov* at 6:04 PM 4/17/2002

Anne, your description of how communities and linkages evolve is quite exciting. It's fascinating to imagine this initially pristine (or rather 'uninhabited') system, where we only have the hydrologic cycle as a dominant transport mechanism. Then humans come. On the one hand they are dependent on that system, on the other hand they start modifying it. Now there are entirely new processes and mechanisms that get introduced. There are local drivers, like access to hunting and fishing resources. There are also regional factors, like access to raw materials.

Just like you say. These drivers act differently. The outside effects tend to be more focused, concentrated and short-term. The population of Khibinogorsk in the Kola grew from 200 to 17950 in one year (1930) and then almost doubled during the next year. Distributed grid-based connections get replaced by vector connection, when roads, airports, pipelines and electric lines are built. Material and energy gets transported so much faster and directly from point A to B. It is practically non-existent in between these end points. That's quite a change. But then it is unclear how long this perturbation can last? Are we just seeing an episodic flash on the historic screen and then everything will settle back to the original hydrologic cycle? Or this flash can tumble the whole system over a bifurcation point into an entirely new state? I guess we're back to the question about scales.

Post Title: Re: Land Use Planning and Climate Change (Henry Huntington)

Posted by: *mjcook* at 6:10 AM 4/18/2002

Although the workshop has ended I want to thank you for letting me participate from the gulf coast of Texas. We are discussing building codes, etc. here and issues you raise certainly are related to what we do. Citizens and community planners definitely need to be aware of the research that scientists are doing and what the environmental effects of human interaction on a barrier island may be for the future. These workshops are such a great learning experience for me so that I may in turn help my students. Marilyn Cook

HARC Online Workshops > Implications of Hydrologic Change > Study of long-term changes of fauna in the Arctic seas based on collections and databases.

Post Title: Study of long-term changes of fauna in the Arctic seas based on collections and databases.

Posted by: Igor S. Smirnov at 1:55 AM 4/17/2002

Study of long-term changes of ophiurid fauna (ECHINODERMATA, OPHIUROIDEA) in the Barents Sea based on database "OCEAN".

A.A. Golikov, I.S. Smirnov, A. Rachor *, D. Piepenburg **

Zoological Institute RAS, St.-Petersburg, Russia; * Alfred Wegener Institute, Bremerhaven, Germany; ** Institute of Polar Ecology, Kiel, Germany

Distribution of Barents Sea brittle-stars during 1840-1992 and influence of climatic changes on it were studied within the framework of the INTAS project "Fluctuations of marine zoobenthos in relation to climatological variability".

Materials on ophiurids stored in databases of Zoological Institute (system "Ocean", authors - I.S. Smirnov, A.L. Lobanov, A.A. Golikov) and data from literature and courteously placed in our disposal by N.A. Anisimova (MMBI) were processed with the use of the program Primer (version 4.0). Cluster analysis (Bray-Curtis coefficient was assumed as a measure of similarity) and multi-dimensional scaling (MDS) were carried out.

Relatively well investigated during the observed period region in the central part of the Sea (from shore up to 76 N, 25-40 E, depth range 0-300 m) was selected for the analysis. Such a choice was stipulated by the necessity of minimizing the difference in a number of samples during various periods and close position of the biogeographical border separating Atlantic boreal and Arctic biogeographical areas. The pattern of climatic changes accepted by Ju.I. Galkin (1974-1987) was selected to determine the influence of a climate on brittle-stars distribution: before 1920 (cooling), 1920-1962 (warming), 1963-1984 (cooling) and after 1985 (warming). The region was divided into 3 parts: 25-30 E, 31-35 E and 36-40 E. The analysis of data both on the whole region and on separate parts during chosen periods was carried out. The analysis of the total data set on brittle-stars species composition in a whole region has shown large similarity in the fauna structure during cooling periods (87%). While during both warming periods the similarity with this cluster did not exceed 63%. The analysis of subregions based on list of species and list of their biogeographical groups has revealed a significant difference of cooling period before 1920 from other periods. Cooling period 1965-1984 could not be separated from warming periods in the fauna structure. MDS based on the list of species has shown, that central and eastern regions during cooling period before 1920 were more similar with central region during warming period after 1985. The same analysis, based on biogeographical data, has demonstrated high similarity of the fauna structure in western region during cooling period 1965-1984 and central region in warming period 1920-1962. The tendency of the Arctic fauna to spread in southwestern direction during cooling periods may serve the explanation of that.

During warming period 1920-1962 many samples of zoobenthos were collected but the number of brittle-stars in them was comparatively low. The warming period after 1984 was poorly represented in a data set. This resulted in a low number of ophiurid species, registered during these periods, and high similarity of warming periods with well investigated and rather rich in a number of species cooling periods.

Arctic species were represented in a data set only during cooling periods. Boreal-arctic and boreal ophiurids did not show the similar pattern. In general distribution of Arctic forms has demonstrated higher similarity with that of boreal- arctic (90%), and the boreal complex of brittle-stars species was similar with the first cluster only on 61%.

Not only a facilitation of the zoologists' work on manual collection of information from stations and collections lists and dotting maps but also an opportunity of quick visualisation of information on findings of animals from collections, stored in museums, were the advantages of information retrieval system "OCEAN" and cartographic system "ZOOMAP" (authors - M.B. Dianov and A.L. Lobanov).

Such kind of software may be considered a prototype of information retrieval systems that will be helpful in analysis of long-term faunistic changes. Involving paleontological materials and dynamically changing shapes and positions of continents would support a quick analysis of various hypothesis of taxa distribution dotted on maps of geological reconstructions. That will make possible to restore the history of various regional faunas formation and to study both climatic and geologic influences on the biota.

Systems "OCEAN" and "ZOOMAP" had given the opportunity to enter data on more than 2600 stations and 8 species of brittle-stars (more than 1000 findings) during relatively short term. The use of collection materials makes it possible to dynamically check results of analysis.

HARC Online Workshops > Implications of Hydrologic Change > Feedbacks to global climate

Post Title: Feedbacks to global climate

Posted by: *Larry Hamilton* at 7:23 AM 4/13/2002

Through snow/ice albedo and thermohaline circulation, Arctic freshwater cycles could influence the global climate system in rapid nonlinear ways. That prospect seems alarming, and an obvious target for research. What can we say about it from studies now under way? What further work is most needed?

Post Title: Re: Feedbacks to global climate (Larry Hamilton)

Posted by: *Larry Hinzman* at 3:15 PM 4/14/2002

The implications of a changing hydrologic regime in arctic regions and the impacts to society are certainly broad.

There are impacts to the individual ---

- hunting
- fishing
- traveling
- safety
- predictability
- other subsistence activities

Impacts to the local community ---

- water supply
- snow accumulation
- bank erosion
- tourism
- access
- flood frequency

Impacts to industry ---

- construction
- maintenance
- exploration
- restoration
- fisheries
- hydroelectricity

Impacts to the global community ---

- carbon balance
- climate dynamics
- major food resources
- shipping
- thermohaline circulation
- fire frequency

Potential consequences are easy to envision. More difficult is detecting the occurrences of such impacts. Even more difficult still is mitigating or preventing negative impacts.

Post Title: Re: Feedbacks to global climate (Larry Hinzman)
Posted by: *mrawlins* at 6:43 AM 4/15/2002

Impacts to the local community ---

- * water supply
- * snow accumulation
- * bank erosion
- * tourism
- * access
- * flood frequency

Assessing human impacts of a changing Arctic is indeed a challenge. At the community level, terrestrial hydrologic models may help us better understand the spatial and temporal variability of the high-latitude water cycle. In more temperate regions, databases for landscape attributes such as population (and population changes), land use, nutrient inputs to the landscape, etc. are becoming useful tools in environmental analysis. Given how the Arctic is such as remote region, one may ask how human attribute databases can be improved, and how can they be used to help assess impacts in the Arctic. At a most basic level, one may ask if a census--used in many parts of the world on a semi-regular basis--is meaningful in the Arctic? Are we able to adequately characterize the communities which may be impacted? If so, how can we improve these databases, and how can they be best utilized in innovative ways in the context of hydrologic models?

Post Title: Re: Feedbacks to global climate (mrawlins)
Posted by: *Henry Huntington* at 11:12 AM 4/15/2002

I like the idea of characterizing Arctic communities' relationship to the hydrological cycle. That could help develop a set of indicators for which databases could be compiled (retrospectively where possible, prospectively otherwise). I wonder if it makes sense to do that in a few communities to start with, to explore the idea and to be able to get into some detail. Then, based on what we find from that exercise, we can consider expanding the scope of the database to other communities. This raises some questions of scaling, etc., but could be a good way of getting started. Any thoughts on how we'd go about a project like this?

Post Title: Re: Feedbacks to global climate (Henry Huntington)
Posted by: *mrawlins* at 9:33 AM 4/16/2002

Making connections between Arctic communities and the hydrological cycle is indeed an important part of Arctic change research. One avenue to explore might be to see how, when and where water supplies are drawn. How many communities rely on snow throughout winter? How many store water? Where are the impoundments located? How do they affect the water cycle? Studies of this nature may be useful in shaping policy in the future. I would think that linking databases popular in GIS studies (population, land categories, etc) along with water budget models may be a start.

Another relationship which could be investigated is water stress. We normally do not think of water shortages in the Arctic. But is this a good assumption under present global change scenarios? If there may be shortages in the near future, where might they occur and how could the impacts be mitigated. We know which areas have seen significant rises in surface air temperature. Studies which address the issue of changing water resources may be as important. Are statistics on water consumption (common in communities in many parts of the world) available for Arctic communities? If so, these numbers could be linked to hydrologic models to explore supply/demand relationships.

Post Title: Re: Feedbacks to global climate (mrawlins)

Posted by: *reportem* at 2:46 PM 4/16/2002

The thermal changes in areas such as Prudhoe Bay make it necessary not only to alter the depth of refrigerated pilings on the major structures but also to monitor the road beds and drill pads at this huge site.

Is there a change brought about in the tundra peat biomass by slight increases of temperatures? The shoreline peat is more vulnerable than the peat in the unexploited interior regions. Tundra plants may increase at the expense of the peat substrata in which they are rooted. The consequence of this will affect the hydrology of the permafrost.

Post Title: Re: Feedbacks to global climate (Larry Hinzman)

Posted by: *Claude Duguay* at 5:58 PM 4/16/2002

Larry,

There are two specific impacts to the local community I can think of that are likely to happen (or may already be happening) under climate warming. One is the decline in lake levels observed in various regions of the Yukon and Alaska. The other is a decrease of the bearing capacity of lake and river ice and its impact on transportation in winter (ice roads).

1) Water level of lakes:

During the last five or six years, residents of communities such as Old Crow, Yukon have repeatedly commented on a drying trend they see in local wetlands, in particular the Old Crow Flats. Similar comments have surfaced in Fort Yukon about wetlands of the Yukon Flats. In Old Crow people are alarmed about this trend because it seems to be something new within the past 15 or 20 years. Some people even fear the Old Crow Flats is drying up. This is of great concern to them as the Flats is a place they have traditionally hunted and trapped, and which they view as their "breadbasket". Recent satellite imagery and aerial reconnaissance photos of the Old Crow Flats have revealed several major lakes and a number of smaller ones that have undergone drastic declines in water levels. Many other lakes show less drastic signs of declining water levels. Local residents, the First Nation Government in Old Crow, and the local Renewable Resource Council are very interested in learning more about what is happening and why.

The lakes of the Old Crow Flats are dynamic, exhibiting cycles of expansion, coalescence, draining, and refilling that are probably typical of shallow thermokarst lakes throughout the arctic. It is not surprising that some lakes would be in the drying or draining phases of this cycle

at present, but it appears there now are an inordinate number that are drying or draining as opposed to filling or growing in size.

If the Flats are indeed showing a drying trend, it is important to understand the effects of this on the ecosystem, including the local people. For example, in the first few years drained lakebeds typically develop lush growths of graminoid vegetation, which provide forage for moulting White-fronted Geese and possibly American Wigeon. Later, a luxuriant growth of willow develops, which is very attractive to the summer population of moose in the Flats. Lakes that are partially drained usually have abundant emergent vegetation and are used as breeding, feeding and moulting areas by dabbling ducks such as American Wigeon, Pintails, and Mallards. On the other hand, moulting diving ducks such as Scaup and Barrow's Goldeneye use deeper lakes with little emergent vegetation but abundant submergent vegetation. Declining water levels in these lakes would eventually force moulting diving ducks to abandon them. Muskrats, which have long been the economic mainstay of spring trapping on the Flats, could also suffer in the long run from declining water levels as more and more lakes freeze to the bottom in winter.

2) Bearing capacity of ice and winter transportation:

Climate scenarios predict an increase in winter precipitation for the Arctic. For some regions, this could mean an increase in the proportion of snow ice. The bearing capacity of snow ice is less than that of clear ice. For example, if one encounters eight inches of ice made up of four inches of white ice on top of four inches of clear ice, the white ice should be considered equal to only two inches of clear ice. Therefore, this ice sheet (two inches equivalent clear ice plus four inches actual clear ice) is the same as a six-inch ice cover for the purposes of determining the load it can support (source: CRREL). A greater proportion of snow ice would likely have an impact on winter transportation in the North. Some numerical ice models provide a means of determining the proportions of snow ice and clear ice under present climate conditions and future scenarios. This, I believe, would be a useful application of a numerical model.

HARC Online Workshops > Human Influences on Hydrologic Processes > Introduction

Post Title: Introduction

Posted by: *Larry Hinzman* at 4:06 PM 4/9/2002

The hydrologic cycle is perhaps the most direct linkage between arctic regions and societies in more temperate regions. As populations grow and land use changes, impacts to the hydrologic cycle may become more apparent with more significant effects. What studies need to be completed to detect these changes, attribute their influences and project their long-term impacts? Such changes are likely to be more dramatic in arctic regions because our environment is so near the phase change temperature of water. As an ecosystem proceeds through threshold changes associated with thawing, dramatic changes may be apparent within a short period of time. The feedback effects that accompany these ecosystem changes and the long time frames associated with recovery from disturbances may accentuate the importance of these issues.

Post Title: Re: Introduction (Larry Hinzman)

Posted by: *Larry Hamilton* at 7:06 AM 4/13/2002

Certainly the Arctic, most notably in Russia and Canada, is downstream from subarctic or temperate regions where climatic changes will have a large effect on water flowing into the Arctic.

The reverse flow is also of interest. Relatively fresh water leaves the Arctic through Fram Strait and the Canadian Archipelago, potentially affecting major commercial fisheries in the Labrador, Barents and Nordic Seas. For example, two large salinity anomalies (composed of cold, low-salinity Arctic-origin surface water) circulated around the northern Atlantic in recent decades, with sometimes profound effects on fisheries -- and on the human communities that depended upon those fisheries. These events show a connection between Arctic hydrological shifts and the fate of individuals, businesses and communities outside of the Arctic.

Can we identify other recent or potential examples? What are the larger-scale implications of the hydrological changes now taking place in the Arctic? Put another way, are there good reasons for non-Arctic residents to care?

Post Title: Re: Introduction (Larry Hamilton)

Posted by: *mrawlins* at 3:26 PM 4/15/2002

Changes in surface air temperature over the past several decades, across not only parts of the Arctic, but also midlatitude areas seems to have a significant effect on the Arctic hydrological cycle. Changes in active-layer thickness may be occurring, which has the potential to affect carbon storage (although some have argued that large-scale decreases will become a net sink for carbon) and damage buildings/infrastructure built on ice-rich soils. Generating accurate benchmarks for permafrost extent and soil moisture content seems to be a worthwhile goal by which future change may be assessed. Understanding feedbacks between air temperature increases, the hydrological cycle and permafrost would be important steps as well. For example, how much water would be released to rivers (and hence the Arctic Ocean) should average active-layer thickness increase by X mm over the next several decades?

Significant increases in midlatitude air temperature may also allow greater amounts of moisture to be transported across the southern boundary of the Arctic basin, which could alter the water cycle. Understanding and quantifying this flux would be an important step in monitoring the changing water cycle. Along these lines, how much Arctic precipitation is "recycled" vs. how much is transported from the midlatitudes. Are GCMs helpful here? Other models?

It would seem that given the hypotheses that significant changes in the Arctic may trigger a major shift in climate modes across the globe (changes in thermohaline circulation or Arctic ice/albedo feedback) persons in other areas may want to take interest, although this may be a bit larger in scale than the discussion warrants.

HARC Online Workshops > Human Influences on Hydrologic Processes > Landscape Change

Post Title: Landscape Change

Posted by: *Henry Huntington* at 6:13 PM 4/11/2002

Worldwide, land use change is a major environmental impact in many ways. In the Arctic, a prime example is de-vegetation by reindeer overgrazing. Are there other instances of significant land use change impacts in the Arctic? And how does land use change interact with hydrology? A study might begin by identifying the significant land use changes (grazing, development, hydro dams), and then the ways that they affect hydrology. Then, the implications of hydrological change for physical and biological systems, with eventual feedbacks to people.

Post Title: Re: Landscape Change (Henry Huntington)

Posted by: *Matt Berman* at 12:13 PM 4/13/2002

Three of the largest rivers discharging into the Arctic Ocean -- the MacKenzie, Ob, and Yenisey -- derive a large portion of their water from the north temperate zone. Already there is significant agricultural development near the headwaters of these rivers -- for example, agricultural and hydroelectric development in the Peace River valley. All three rivers also have large hydroelectric dams in the upper reaches that significantly modify the seasonal flow regimes.

If climate continues to warm over the next 50 years as many models project, then agricultural activities, with accompanying expansion of settlement and other forms of development, could expand dramatically in all three river basins. New dams, or more active management of seasonal flows to support electric power and irrigation demands might also occur. This expansion of agricultural development, dams, and population growth in the north temperate zone within these river basins is likely to far exceed the changes in development within the Arctic itself. If such expansion indeed occurred, it would likely cause significant changes in runoff regimes, sediment loads, and contaminant transport to the Arctic Ocean. The MacKenzie Basin study (Cohen et al.) addressed some of these possible changes in that basin, but I do not believe that the potential implications of the cumulative effects of changes in Asia and North America have been investigated.

Post Title: Re: Landscape Change (Henry Huntington)

Posted by: *ekasischke* at 11:55 AM 4/15/2002

A major driver of land cover change in the sub-arctic (boreal region) of North America and Eurasia is disturbance by insect, disease and fires to the forests of these regions. These disturbances can impact very large areas over very short time periods - For example, fire damages some 3 million ha/year in NA, and 10 to 12 million ha/yr in Russia. Fire has major implications because of its interactions with climatic, hydrologic, and biological processes. Fire strongly changes the atmosphere/land interactions, and also regulates the deformation-reformation of permafrost. Fire tends to be very regionally episodic in its occurrence, e.g., large outbreaks of fire are local in nature, and can affect 3 to 5% of the total land surface in a single year. In North America, the annual area burned during fires has doubled between the 1960s and 1990s. While human activities contribute to some degree to fire activity, throughout much of the sub-arctic region, natural causes (Lightning) are the primary sources for fire. For example, in

NA, while humans cause >90% of all fires in Canada and Alaska, human caused fires result in less than 10% of the total area burned.

Post Title: Re: Landscape Change (Henry Huntington)
Posted by: *Daqing Yang* at 1:00 PM 4/15/2002

I agree that we need to understand the impact of dams on hydrologic regimes, because without this knowledge it is almost impossible to study the interactions between hydrology and climate systems in the high latitude regions. I support Henry's idea for HARC to initiate a study to identify the significant land use changes including hydro dams and to investigate the implications of hydrological change for physical and biological systems, with eventual feedback to people.

I think we need to do several things. First we need to clearly document the dams in the northern river basins, including their size, year of completion, and ways of operations. I found this is not an easy task, at least for the Siberian rivers, because we do not have enough information. Second, we need to examine and quantify the impact of dams on river hydrology, particularly on seasonal streamflow regimes. To do this we need long term runoff data. Fortunately long-term observation records are becoming available recently for some northern regions. Systemic analysis of these data with a special emphasis on human impact to the arctic environment and its change will benefit arctic science research at large.

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Post Title: Re: Landscape Change
Posted by: *subarctic* at 1:16 PM 4/15/2002

For over 27 years the Dalton Hwy, Alaska's access route to the Arctic Coastal Plain, has altered the snowmelt pattern in its immediate vicinity due to dust on the snow. In response, waterfowl have adapted to the snowless thread extending significantly into the snowy arctic coastal plain and can be found following that narrow band much farther north during their spring return than they would have in a natural condition. The State of Alaska is planning to "pave" the Dalton Hwy with a hifloat asphalt surface treatment dust pallative. I wonder what will be the result of removing this 27 year old situation on waterfowl migration habits. I expect there will be a perturbation in the survival rate that may be driven by available food or space to hang out in until a few generations get used to the new conditions. The reduced dust may benefit the roadway in that the ground next to the road will not receive as much solar radiation because the snow is around longer.

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Post Title: Re: Landscape Change (ekasischke)
Posted by: *mrawlins* at 9:54 AM 4/16/2002

The effects of fire on the water cycle is an interesting topic. The evolution of tree species with time following large fires is fairly well understood. Understanding the impacts of fire and vegetation evolution on Arctic surface hydrology would likely help us understand how the water system may respond under a changing Arctic landscape. Statistical model (Monte Carlo, stochastic methods) would be an interesting experiment to investigate the relationships between vegetation evolution and water in the Arctic. One would assume that the growth of vegetation with increasing air temperatures (northward progression of tree limit) is similar to the growth seen following a large fire. If this is true, an interesting relationship could be explored.

Post Title: Re: Landscape Change (Daqing Yang)
Posted by: *Alex Shiklomanov* at 10:04 AM 4/16/2002

I think we should better understand the dam effect on the hydrological regime Arctic rivers to separate the local anthropogenic impact and watershed response to global change. I agree with Daqing that it is hard to do any conclusion about climate-hydrology interaction for some arctic regions such as Yenisey drainage basin where total storage of reservoirs is about 450 cub. km. and net storage is about 175 cub. km. The powerful reservoirs cascade allows realizing the seasonal and even over-year regulations. The winter discharge in the down stream of Yenisey river has increased 2 times for last 20-30 years and it is important to identify the dam and climate contributions in this increase. A lot of other large rivers in the Arctic drainage not affected by dams show the similar winter discharge increase. That is why many researchers including myself consider these changes as a result of increase in temperature, ground storage and permafrost degradation. But we have to be very careful making these conclusions because even natural river at the first sight may have enough anthropogenic impact to lead to the mistaken deductions. For example, Lena is often considered as a natural regime river but there is a dam on one of the largest tributary Vilui constructed in the end of 60th and contribution of the dam in Lena discharge re-distribution is not well-studied.

I think we should use a hydrological models to reconstruct the natural regime of anthropogenically affected rivers. For instance the reconstruction of natural Yenisey discharges was made in AARI up to 1990 and it may be easy done for last decade.

Another way to study the interaction between climate and hydrology is to apply these investigation to the natural large enough watersheds located in various land-cover and climate conditions. Big problem is that we do not have enough observational network on such rivers and our observational capability has significantly decreased for last decade. We should identify and support these gauges as well as downstream sites located on rivers flowing to the ocean.

Post Title: Re: Landscape Change (subarctic)
Posted by: *Larry Hinzman* at 11:42 AM 4/16/2002

This is a really interesting aspect of hydrologic change with impacts to wildlife that I had not considered. In the spring, snow does melt next to the road much earlier than snow even a few hundred meters distant. This does greatly influence wildlife behavior as the geese, cranes, ducks and swans congregate in that snowfree lane along the road. It is wonderful for wildlife viewing as it is like driving through an aviary. Also, fox, bears and wolves come to graze, prey on the birds or eat road-killed caribou. Judging from a windshield survey, it is difficult to envision how low the population densities of wildlife really are.

The dust also increases thermokarst near the roads. This improves local drainage and causes the soils to markedly dry. As the soils dry, tussock tundra gives way to shrubs. In the big scheme of things, the road may be a relatively minor footprint, but when the footprint is also a corridor, then it has more significant implications.

Post Title: Re: Landscape Change (Larry Hinzman)
Posted by: *Henry Huntington* at 12:47 PM 4/16/2002

I've heard concerns expressed about roads and so on as corridors for invasive species. The thermokarst disturbances may also provide habitat for new species. How significant this is in terms of overall ecology I don't know, but if species changes are anticipated, a corridor along which species can move north more rapidly may change the patterns and dynamics of that kind of change.

Post Title: Re: Landscape Change (Henry Huntington)
Posted by: *ekirk* at 1:40 PM 4/16/2002

I think that landscape changes take place also during rapid industrialization like that which took place on the Kola Peninsula. Mineral extraction industries, power plants, and other infrastructures like railroads and shipping ports produced large scale changes in forests and vegetation.

Post Title: Re: Landscape Change (ekirk)
Posted by: *Alex Shiklomanov* at 2:50 PM 4/16/2002

Just another good example is Norilsk region (Taimyr peninsula) where all infrastructures are located in continuous permafrost zone and all land cover changes are irreversible for a long time.

Post Title: Re: Landscape Change (mrawlins)
Posted by: *jason_beringer* at 4:23 PM 4/16/2002

The net effect of tundra fires in terms of the energy balance is to increase the amount of net radiation available at the surface because of a decreased albedo. In addition the heat flux into the ground is increased (which will affect permafrost). Of major interest is the subsequent large increase in atmospheric heating and slight increase in evapotranspiration. So even after burning the impact is to increase air temperature and evaporation that will have a positive effect on the regrowth of the ecosystem.

The shift of the treeline is also interesting and in terms of human impact is currently ultimately driven by enhanced warming. There has been some debate over whether the position of treeline (a large landscape feature) is being driven by climate or in fact exerting an influence on climate itself (in particular does it control large scale synoptic features such as the Arctic front). We have addressed this question recently using surface flux measurements, historical synoptic analysis and regional modeling. Our findings suggest that treeline in fact does not influence the position of the Arctic front but is rather controlled by it. Trees are able to grow in the warmer air mass to the south of the front. The front is likely controlled by land/sea heating contrasts and focused by topography (ie the Brooks range). So the Arctic front which somewhat influences precipitation may be a relatively static feature and stable in the landscape.

Post Title: Re: Landscape Change (ekirk)

Posted by: *ffjam* at 1:33 PM 4/17/2002

Industrial activity in the North has had dramatic effects on the hydrologic balance, and not just during periods of rapid industrialization. In Alaska, the Prudhoe Bay waterflood project of the 1980s had a large, but not yet clearly specified impact on the nearshore regime. Technological changes in techniques for constructing roads, drill pads, and air strips, and particularly the recent use of fresh water for ice roads, has changed the surface albedo and may have had other effects. Regulators I've interviewed believe these changes largely have been environmentally benign, with the exception of small numbers of over-wintering fish trapped by in-take hoses. I'd say that changes in amounts and nature of industrial use of water should be on the list of topics to be studied.